ELEVENTH ANNUAL REPORT

of

Pasture Research

in the

Northeastern United States
State College, Pennsylvania

1947

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Eleventh Annual Report of Pasture Research in the Northeastern United States

U. S. Regional Pasture Research Laboratory
State College, Pennsylvania

Division of Forage Crops and Diseases
Bureau of Plant Industry, Soils, and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture
and
The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

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Copies of this report were sent to all organizations involved in the development of the present pasture research program in the twelve Northeastern States and in addition one copy to the Director of each of the following State Agricultural Experiment Stations--Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Carolina, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, Virginia, and Wisconsin; three copies to Canada as follows--Dean of Agriculture, University of Saskatchewan, Saskatoon, and Dominion Agrostologist and Main Library, Department of Agriculture, Ottawa; and one copy to each of the following--The Library, School of Agriculture, Cambridge, England; Director of the Welsh Plant Breeding Station, Aberystwyth, Wales; Director of the Swedish Seed Growers Association, Svälof, Sweden; Director of the Waite Agricultural Research Institute, Adelaide, Australia; Librarian, Division of Plant Industry, Council for Scientific and Industrial Research, Canberra City, A. C. T., Australia; Director, Grasslands Division, Palmerston North, New Zealand.

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REPORT

OF

PASTURE RESEARCH

IN THE

TWELVE NORTHEASTERN STATES

FOR THE CALENDAR YEAR 1947

INTRODUCTION

This Eleventh Annual Report of pasture research in the twelve Northeastern States is organized and presented in a manner similar to that of its immediate predecessor. Part I consists primarily of brief accounts of progress on work covered by formal project outlines drawn up between state stations and the Laboratory; Part II is concerned with work underway at the Laboratory, but not carried on in direct cooperation with state stations; and Part III covers forage crop investigations at the state stations but not carried on in direct cooperation with the Laboratory. This somewhat arbitrary division is made merely for convenience in presentation. In its broadest sense pasture research in the Northeastern States is cooperative regardless of whether the work is supported by State or Federal funds. The responsibility for the preparation of Part I rested largely with the project leader concerned and of Part II with the Laboratory Staff. The Collaborators were responsible for compiling the material presented in Part III.

The list of publications at the end of the report may not be complete for the year but it does include all those originating at the Laboratory and those originating elsewhere in the region, citations to which were sent in with the progress reports.

Personnel changes at the Laboratory during the year included the resignations of E. J. Dollinger, technical assistant, and Marion F. McCartney, Secretary. Miss Helen Harvey replaced Mrs. McCartney and Mrs. Mildred R. Baustian was added to the secretarial staff.

There was one change among the Collaborators. At his request, Director W. B. Kemp of the Maryland Agricultural Experiment Station was replaced by Professor A. O. Kuhn.

The ninth Collaborators' Meeting was held July 23 and 24 at State College, Pennsylvania. The main feature of the meeting was the discussion centered around the reports by three regional committees--Soil Aspects of Pasture Management, Aspects of Pasture Management Other than Soils, and Strain Evaluation. At the suggestion of the Collaborators, a committee was appointed to consider utilization, particularly animal nutrition aspects of forage crops research. A report of the Collaborators' Meeting was prepared and sent to all persons attending the meeting.

PART I

COOPERATIVE RESEARCH BETWEEN STATE STATIONS AND THE LABORATORY

FOUNDATION SEED STOCK OF LADINO CLOVER

Consistent with plans developed previously (1946 Annual Report, page 3), the clones of Ladino selected to serve as foundation material for the new increase were sent to the Soil Conservation Service Nurseries and were increased by them for the field planting at Bellingham, Washington. A total of 10 acres was planted in an area isolated from any other plants of white and Ladino clover. Because of extensive damage from rabbits, no seed was obtained from this planting during 1947. Since that time, however, the area has been fenced and it is anticipated that seed will be produced during the summer of 1948. Part of this seed will be used for testing purposes and the remainder will be made available to Crop Improvement Associations of several states and will be used by them for the production of certified Ladino. A meeting of the Ladino Clover Improvement Conference was held at the Pasture Laboratory on September 18, 1947.

REGIONAL STRAIN TESTING

The plans developed previously (1946 Annual Report, page 3) for initiating and carrying out a regional testing program have been carried forward insofar as possible subject to the limitations of facilities in the region. The clones that were distributed in the fall of 1946 have been planted and established at each of the cooperating stations. It is anticipated that the first critical records on performance of these clones will be obtained in 1948. Development of this program to the extent that is consistent with needs is limited by lack of facilities in the Northeastern Region for increase of the clonal material, production of seed for testing purposes, and adequate plot tests of the clones and their seed progenies.

DACTYLIS GLOMERATA BREEDING (WITH MARYLAND AND DIVISION OF FORAGE CROPS AND DISEASES)

Title: Selection, Inbreeding, and Crossing to Obtain Orchard Grass Strains Adapted Particularly for Pastures in Maryland.

Leaders: For the Maryland Agricultural Experiment Station - A. O. Kuhn
For the Division of Forage Crops and Diseases - M. A. Hein and R. E. Wagner.
For the Pasture Research Laboratory - W. M. Myers.

At Beltsville, Maryland

Polycross Nurseries: Two polycross nurseries were established in the spring of 1947. One of these consists of 84 clones selected in 1946 from

the breeding nursery and the isolation blocks at Beltsville. Each of these clones was replicated 12 times. The second nursery is composed of 225 different clones from material obtained from the Pasture Research Laboratory in the summer of 1946. These clones are replicated 15 times.

Both nurseries were rather slow to become established, but except for a bad spot in the middle of the field, most of the plants made considerable growth by the end of the season.

Isolation Blocks. Some of the more outstanding clones were selected from the isolation blocks and the remainder abandoned. These selections were included in the 1947 polycross nursery with the other Beltsville selections.

Further Selection and Increase of Maryland Strains. Due to the late freeze in the spring no seed was harvested from the selection and increase nursery of the Maryland Hay and Pasture strains. The nursery was fertilized and otherwise maintained to provide for the best possible seed production in the summer of 1948. Prior to harvesting the seed in 1948 for increase and testing purposes, the nursery will again be rogued and the outstanding individual plants selected for further breeding purposes.

Strain Trials at the Agricultural Research Center: This test consists of 16 strains of orchard grass seeded in the fall of 1944 in mixtures with red and Ladino clover to determine their performance under actual grazing conditions. The strains included in the test are Tammisto, Finnish Late Hay, Brage, S-26, S-143, the Maryland Hay and Pasture selections and 9 new strains from isolation plots grown at Beltsville and the Pasture Research Laboratory.

On the basis of plant counts the Maryland Hay and Pasture strains have been consistently outstanding during the three years of the study. Likewise, in yield these strains have ranked high, particularly the Maryland Hay strain.

At the end of the 1947 season observational notes were taken as well as plant counts with the point quadrat and separations were made on some of the plots. Yields were also taken three times during the summer. In general, these data corroborated the results of the first two years.

As a result of this and other tests, it seems highly desirable to increase the seed supply of the Maryland Hay and Pasture strains as rapidly as possible to permit more extensive testing and to avoid further delay in their release. These strains have been consistently high yielders and have persisted well in mixtures with Ladino clover. One of the outstanding features of these strains is their very apparent compatibility with Ladino clover as evidenced not only by the amount of grass in the mixture but also by their ability to remain uniformly distributed and not become clumpy.

At State College, Pennsylvania

Selection and Evaluation of Plants. From the source nursery established in the spring of 1945 (1945 Annual Report, pages 4 and 5) consisting of 5,500 plants from new collections, varieties, and strains of orchard grass, 85 plants were selected. These were increased vegetatively and planted in a polycross block consisting of 15 replications in the fall of 1947. During the summer of 1947, notes were taken at several times on performance of 364 clones that were in a replicated polycross block (1945 Annual Report, page 5). Of these, 236 clones had been in polycross tests previously while the remainder were new clones being tested in replicated plantings for the first time. On the basis of winter hardiness, leafiness, disease resistance, plant type and recovery following mowing, 112 clones were selected for further study. During the fall of 1947 these clones were planted in a polycross block consisting of 10 replications with five plants of each clone per replication. Observational data were taken on the plots established with polycross seed harvested from 102 clones and planted in the spring of 1945 (1945 Annual Report, page 5). The parental clones of these polycross progenies were included among the 364 clones referred to above. Clonal performance based upon the progeny tests in replicated plots agreed quite well with the relative ratings of these clones based upon their behavior in the replicated polycross plot. The results suggest that elimination of clones on the basis of their behavior in replicated clonal plantings may be a fairly reliable procedure.

Isolation Plots for Production of New Strains. On the basis of data obtained from the replicated clonal test and from the polycross progeny tests of these clones a number were selected for use in the production of new strains. These were segregated on the basis of maturity date into seven groups ranging from early to late maturity. Each group was planted in an isolation plot in the fall of 1947. It is anticipated that small quantities of seed will be produced on these plots in the summer of 1948.

Strain Trials. Because of pressure of other work and inadequacy of field labor, it was impossible to take yield data from the strain trials of orchard grass (1945 Annual Report, page 5). Observational data on earliness of spring growth, vigor of hay yield and vigor of aftermath growth were taken on these plots. Because of the nature of these data, it does not seem justifiable to draw conclusions as yet regarding the relative merits of these orchard grass strains.

MEDICAGO SATIVA BREEDING
/WITH CORNELL (NEW YORK), NEW JERSEY, RHODE ISLAND, AND THE DIVISION OF FORAGE CROPS AND DISEASES/

Titles: Breeding Improved Alfalfa for the Eastern United States.
Breeding and Testing Alfalfa for Pasture and Forage.
Alfalfa Breeding.

Leaders: For the Cornell University Agricultural Experiment Station - S. S. Atwood, R. P. Murphy, H. A. MacDonald, and Paul Grun.
For the New Jersey Agricultural Experiment Station - G. H. Ahlgren.
For the Rhode Island Agricultural Experiment Station - T. E. Odland.
For the Division of Forage Crops and Diseases - H. M. Tysdal.
For the Pasture Research Laboratory - W. M. Myers and K. W. Kreitlow.

At Ithaca, New York

The 1947 data from this project have been summarized in tabular form to be included in the Annual Report of the Uniform Alfalfa Nurseries. Brief summaries of the outstanding results from these plantings are included here:

Clonal Nursery. This nursery, planted from rooted cuttings in August, 1946, consists of five replicated 3-plant rows from each of 47 C clones and 41 New York selections. The 1947 hay crop in this nursery was severely infested with weeds, but notes on vigor and leaf spot reaction were obtained on the aftermath growth in September. Leaf spot was less prevalent in 1947 than in 1946 but marked differences between clones were observed in both years. The outstanding clones on the basis of vigor were C-10, 12, 13, 14, 21, 22, 27, 35, 40, 42, 46, 49, 53, and 59. The clones that showed the least damage from leaf spots were C-8, 10, 12, 16, 20, 21, 23, 27, 36, 37, 39, 42, 43, 46, 47, 48, 49, 53, and 56. Some of the New York clones were found to be susceptible to wilt in a controlled test in the greenhouse during the winter of 1946-47. Most of the New York clones are being re-tested this winter, along with several new selections not tested previously. Seventeen of the New York clones were sent to Nebraska in the spring of 1947, and 11 more were sent in the fall.

1945 Observation Nursery. Because of the poor stand that was obtained in this nursery, no notes were taken in 1947, but the nursery was maintained to serve as a source of infection for seedling plants grown in flats planted with A-110, Atlantic, Buffalo and Ranger. These flats were brought in from the field during October, and Dr. Tyler of the Department of Plant Pathology assisted in classifying each seedling for degree of leaf spot damage. No significant differences were found between the four seed lots, but 30 plants with light infection were saved for further study.

1946 Observation Nursery. These nursery rows were cut for hay yield on July 10 and for aftermath yield on September 12. The differences between varieties at the hay cut were not significant, but at the aftermath cut the differences were highly significant.

The notes on leaf spot in the aftermath growth and vigor on October 31 also showed highly significant differences between varieties. Some of the new polycrosses and single crosses included in this nursery were significantly better than the standard varieties. Yields of the diallel single crosses and polycross progenies of C-3, 8, 10, 17, 19 and 21 were summarized to show their general and specific combining ability. The outstanding performer was C-21, with C-8 ranking second, and C-10 and C-17 tied for third. C-3 and C-19 were distinctly poorer than the others.

1947 Observation Nursery. A good stand was obtained for most of these rows, which were seeded on June 27 - 28 at Caldwell Field. Notes were taken on September 13 and the rows were cut for yield on September 23. Highly significant differences were found between varieties in regard to the vigor note and the yield, but no significant differences were noted in leafhopper yellowing. Some of the polycrosses and single crosses were significantly better than the standard varieties.

1945-46 Advanced Nursery. Parts of these two nurseries were combined in the planting of replicated plots made at Churchville in April, 1946. When the resultant plots were cut on July 1 and September 19, 1947, significant differences were obtained between varieties. The outstanding performance was by C-8 x C-10, which ranked first in hay and total yield, and was on the borderline of being significantly better than Cntario Variegated.

1947 Advanced Nursery. A good stand was observed on these plots during the middle of the summer, but by late fall over 90% of the plants were dead. Dr. Tyler was able to isolate several organisms from dead and injured plants, but the cause of this killing was not determined with certainty.

Greenhouse Sterility Studies. Some evidence of cross-incompatible matings was obtained with the families studied in 1946-47. New families, derived from crosses between plants of low self-fertility, are being investigated this winter. Evidence was also obtained that in families of high self-fertility the greater seed set in crosses as compared to selfs could be attributed more to a lower number of seeds per pod than to a lower number of pods per flower pollinated.

Cytological Studies. A technic involving modifications of the Feulgen stain has been developed for permanent sections of flower buds. It is being used to study meiotic pairing and disjunction in clones varying in self-fertility. Quadrivalent pairing has been observed in most clones, but the frequency is not high.

At New Brunswick, New Jersey

Yield and incidence of wilt were noted in a two-year old observational nursery including 40 strains and varieties of alfalfa. 42-1227x1255 Nebr., 49-1282 Nebr., and Atlantic gave the highest yields as a two-year average. It appeared that in general those lines giving the greatest forage yields also showed the lowest incidence of bacterial wilt.

A uniform nursery including 58 strains was seeded in rod rows in the fall of 1946. Unsatisfactory stands resulted in all except the first replication. A single cutting was made in 1947.

Fifteen lines have survived at least partially in the wilt epidemic nursery started in 1945. Five of these showed 80% or better survival after artificial inoculation, with two (C140 N. J. and C141 N. J.) surviving 100%. C141 N. J. also appears to be a particularly good yielder.

A second wilt epidemic nursery was established in 1946, and some of the lines have already been eliminated by the disease.

At Kingston, Rhode Island

Data from two nurseries, one established in 1945 and the other in 1946, were obtained. This is part of the Northeastern cooperative alfalfa breeding program. Excellent yields were obtained from the best strains and varieties. Rhode Island hybrid, A197, continued as a leader. This has now been named Narragansett. Arrangements have been made to have seed of Narragansett produced in Idaho. A small amount was harvested this year, which will be used for tests on farms in Rhode Island. A part of this seed will also be used for increasing the seed producing acreage in Idaho.

Hybrids from Nebraska that appear exceptionally promising for this region include 57-C24, 57-C41, 57-C21 and 57-C48. A polycross nursery has been established at Kingston for the purpose of combining the wilt resistance of these hybrids with the local adaptation qualities of Narragansett. Another uniform strain and variety nursery was also established this year.

At Beltsville, Maryland

The alfalfa work at Beltsville continues to be primarily one of observation on the adaptation and disease resistance of clones and polycrosses developed in the nation-wide cooperative alfalfa improvement program. Some selection is being made in space planted nurseries for resistance to the potato leafhopper, (Empoasca fabae), and for the spreading crown habit, disease resistance, and other desirable characteristics. Tolerance to leafhopper infestation has been observed among some of the plants, but real resistance is difficult to obtain. It is believed, however, that progress can be made in this direction. A number of clones which may be of value as breeding stock, or as components of synthetic varieties have been distributed to other States in the cooperative program. Special attention is being given to such diseases as Rhizoctonia, Fusarium, Sclerotinia, and certain leaf spots.

At State College, Pennsylvania

Selection and Evaluation of Plants. From the 4,900 plants in the new source nursery planted in the spring of 1946 (1946 Annual

Report, page 9), 67 selections were made. These selected plants were transferred to the greenhouse in the fall of 1947 and cuttings from them are being rooted to provide material for a replicated field planting in the spring of 1948. Since it was impossible to conduct the usual greenhouse wilt test on these clones it is anticipated that the rooted cuttings will be inoculated with wilt bacteria just before being transplanted to the field. In the spring of 1947, 33 clones, which had survived from the wilt test of 88 selections made in the greenhouse in 1946-47, were transplanted to the field in 3 replications. During the summer of 1947 records were taken on vigor, disease resistance, resistance to yellowing and recovery growth on the replicated rows of 86 clones which had been transplanted to the field in the spring of 1946 (Annual Report, page 9). In addition there were 55 clones which were not replicated. From these 141, 29 were selected as superior and were made available for distribution through the Eastern Alfalfa Improvement Conference. During the summer, there were heavy epidemics of black stem and of Pseudopeziza leaf spot. Several clones appeared to be resistant to each of these diseases and a few clones showed resistance to both diseases. Records were taken also on 22 C clones which were distributed at random in four replications. These clones, primarily selections from the Nebraska Agricultural Experiment Station, were rather uniformly susceptible to black stem and to Pseudopeziza. They were, however, on the average superior in maintenance of green color throughout the growing season to the selections that had been made at the Laboratory and included among the 141 clones referred to above. The data on behavior of these clones have been summarized for inclusion in the annual report of the Alfalfa Improvement Conference.

Hybridization and Recombination of Characters. A total of approximately 1100 seedlings which had survived the wilt test in the greenhouse in 1946-47 (1946 Annual Report, page 9) were transplanted to the field in the spring of 1947. Approximately half of these seedlings were from crosses involving a rhizomatous parent. The remainder were from crosses of selections from Atlantic with wilt resistant parents. Parents of the 29 clones selected as superior in the replicated plantings during the summer of 1947 were planted in the greenhouse in the fall of 1947 to be used as parental material for crossing. These crosses were designed to provide recombination of resistance to Pseudopeziza and black stem with vigor and persistence of green color.

POA PRATENSIS BREEDING

Title: Breeding and Improvement of Pasture Grasses and Legumes (With West Virginia).
Breeding Kentucky Bluegrass for Improved Pasture Types (With Pennsylvania).

Leaders: For the West Virginia Agricultural Experiment Station - Collins Veatch and J. G. Leach.
For the Pennsylvania Agricultural Experiment Station - H. B. Musser.
For the Pasture Research Laboratory - W. M. Myers and K. W. Kreitlow.

At Morgantown, West Virginia

The three strains of Kentucky bluegrass, that proved resistant to artificial inoculation of stripe smut Ustilago striiformis, were vegetatively propagated in the greenhouse and then transplanted to the field in the spring. The seed production of these three strains was very poor on plots planted in 1944.

Further clonal propagation will be carried out in an attempt to speed up the propagation of these strains. These lines may then be interplanted for seed production.

Because of a shortage of help, progress on this study has not been as rapid as would have been desirable. The experimental work consisted primarily in testing for smut resistance on 17 selections of Poa pratensis, obtained from the Pasture Research Laboratory. Of the 17 varieties tested, 8 were found to be susceptible and 9 did not become infected. However, these negative results cannot be considered conclusive, because the percentage of infection in the susceptible varieties and the susceptible checks was relatively small. Further tests of those selections showing no infection are under way. The susceptibility and possible resistence of the strains tested are shown in the accompanying table:

KB 130 (36)	-	KB 161 (97)	-	KB 170 (3)	-
KB 143 (223)	-	KB 38 (12)	-	KB 21 (2)	≠
KB 176 (22)	-	KB 139 (111)	-	KB 162 (95)	≠
KB 181 (1)	≠	KB 140 (11)	-	KB 172 (14)	≠
KB 96 (1)	≠	KB 164 (97)	≠	KB 114 (12)	≠
		KB 120 (30)	≠	KB 129 (193)	-

Seed of Strains KB 38(12) - and KB 140 (11) - did not germinate very well, and an insufficient number of plants were used.

At State College, Pennsylvania

Work on this project at the Pennsylvania Agricultural Experiment Station has been temporarily discontinued. Similarly, no further work is being done at present on this project at the Laboratory, except for the production of additional seed increases of strain 143 (223).

TRIFOLIUM REPENS BREEDING

Title: Breeding White Clover for Pasture (With New Jersey).
The Improvement of Ladino Clover by Selection and Breeding (With New Hampshire).

Leaders: For the New Jersey Agricultural Experiment Station - G. H. Ahlgren.
For the New Hampshire Agricultural Experiment Station F. S. Prince, L. J. Higgins and P. T. Blood.
For the Pasture Research Laboratory - W. M. Myers and K. W. Kreitlow.

At New Brunswick, New Jersey

Progeny Test of Diallel Crossing System. The production of seed from three crosses of selected parents was continued during 1947. Each cross was made under isolated conditions on the College property. The crosses identified as 6-5 x 6-16, 6-10 x 6-13, and 6-9 x 6-12 produced sufficient seed so that it was possible to seed down small twice replicated plots of each during early September of 1947. The very dry fall limited the growth of this planting and whether or not the planting will survive remains to be seen. The crossing blocks are being retained for further seed production next year.

Open-pollinated Breeding System. A good supply of this seed has been collected from the breeding block during 1946 and 1947. Replicated plots similar to those of the diallel seed were planted for comparative purposes. The plots are 3' x 7' and are straight clover with no grass companion. Seed of commercial Ladino clover was also planted at the same time to serve as a check.

Observations in the fall of 1947 indicated more rapid come-up and more vigor for the commercial Ladino than for any of the controlled crosses.

At Durham, New Hampshire

Crosses were made in the greenhouse during the winter of 1946-47 among the nine parent plants that had previously been selected and certain promising individuals chosen from clover which had been submitted for testing from cooperating stations. During the summer, eight of the nine parents were caged and seed was produced by interpollination with bees. Seed produced from this work will be tested both as individuals and, if enough seed stocks remain, in small plots, in comparison with commercial Ladino. Additional controlled crossing will be done in the greenhouse this winter among promising families. One of the original nine parents previously chosen had to be discarded during the season because it appeared to be infected with mosaic.

At State College, Pennsylvania

Progeny Tests of Ladino Clover Clones. Records were taken during the summer of 1947 on the space planted progeny tests of 49 of the Ladino clover clones developed at the Laboratory. These progeny tests consisted of 100 plants from each clone, the plants being distributed in five replications of 20 plants each. The data from these progeny tests have been summarized and included in the report of the Ladino Clover Improvement Conference. On the basis of these progeny tests, recommendations have been made for the removal of certain of the parental clones from the foundation seed plot in Wash. . There were striking differences among the progenies of the different clones in winter survival, vigor of early spring growth, size and spreading ability of the plants, and frequency of intermediate and small white clover types.

Selection and Evaluation of Plants. From the progeny tests referred to above, 228 new selections were made. These were transferred to the greenhouse during the fall for use in making increases sufficient for the inclusion of these new selections in a replicated polycross block in the spring of 1948. No selections were made from among the 1100 plants from various seed lots of commercial Ladino obtained originally from California, Oregon, Montana, and Italy (1946 Annual Report, page 13). The three lots of material obtained from Italy were particularly inferior in their performance. A majority of the plants was so severely winter killed that little growth was made by these plants during 1947. The plants that survived were intermediate types similar to Louisiana white clover in size and flowering habit. In the spring of 1947 a polycross plot consisting of 103 clones planted in 10 replications was set out in the field. These clones included 53 that have been distributed through the Ladino Clover Improvement Conference for testing at cooperating stations and an additional 50 clones which had been selected from the 1945 polycross block (1946 Annual Report, page 13).

Plot Tests of Polycross Progeny. The percentage of clover was estimated for each plot in the polycross progeny tests seeded with orchard grass (1946 Annual Report, page 13). The average percentage of clover ranged from 16 to 45 for the different polycross progenies. There was, however, a great deal of variation between replications making these differences of doubtful significance. During the summer of 1947 damage by field mice in these plots was so extensive that the stand of Ladino clover in certain areas of the strip was completely destroyed. As a result it has been necessary to discontinue these plots.

TRIFOLIUM PRATENSE BREEDING

Title: The Improvement of Red Clover by Selection and Breeding.

Leaders: For the New Hampshire Agricultural Experiment Station - F. S. Prince, L. J. Higgins, and P. T. Blood.
For the Pennsylvania Agricultural Experiment Station - M. T. Henderson.
For the Pasture Research Laboratory - W. M. Myers and K. W. Kreitlow.

At Durham, New Hampshire

Offspring of the twelve original families are being maintained. The disease-susceptible and weak individuals are being eliminated as they show up. The best selections are being hand-pollinated in the greenhouse. The best set of seed yet secured was obtained in 1947. Testing will continue both in the greenhouse and in the field in 1948.

At State College, Pennsylvania

Resistance to Sclerotinia. During the winter of 1946-47 investigations were begun to determine a satisfactory greenhouse technic for testing for resistance to Sclerotinia in red clover. Seed of 40 varieties and strains of clover obtained from many sections of the United States was sown in rows in greenhouse flats. The strains were replicated 3 times and each individual plot consisted of one row - approximately 75 plants. About 3 weeks after emergence, the seedlings were inoculated by placing cultures of Sclerotinia grown on a wheat-oats medium on the surface of the soil in contact with the clover plants. The inoculated flats were kept in a moist chamber for 10-14 days. Records were taken at two dates--one week and two weeks after inoculation. Damage from the disease was expressed as light, medium or heavy.

Infection was highly variable. Most strains showed a complete range from light to heavy infection among the 3 replications. No strain had a consistently high percentage of uninfected plants. Differences among strains were slight, although a few strains appeared to have somewhat more resistance than the rest. The results of all tests indicated that the new variety, Kenland, formerly known as Southern Selection, had a slightly higher percentage of healthy plants than the other strains, even though most of the plants of this variety were killed. For example, in a supplementary test which included a larger number of plants, Kenland and the Scott strain, a farmer's strain from Lancaster County, Pennsylvania, were compared. There was approximately 5% survival in the Scott strain, and 15% survival in the Kenland strain.

This work was started too late to determine the relation of seedling reaction to resistance of mature plants. Work is under way at present to measure the association between seedling and mature plant reaction, the effectiveness of inoculating large numbers of seedlings as the first step in the selection of red clover plants with resistance to Sclerotinia, and the isolation of resistant plants as a part of the clover breeding program.

Results obtained in these preliminary investigations suggest that none of the varieties currently available has sufficient resistance to Sclerotinia to be of much practical value except as a source of resistant plants in a breeding program.

PHLEUM PRATENSE BREEDING

Title: The Improvement of Timothy by Selection and Breeding.

Leaders: For the New Hampshire Agricultural Experiment Station - F. S. Prince, L. J. Higgins, and P. T. Blood.
For the Pasture Research Laboratory - W. M. Myers and K. W. Kreitlow.

At Durham, New Hampshire

Two strains of timothy, one a late hay type, the other a pasture type, are still in the process of selection, although plantings in the field have been made and seed harvested from both types in our strain building program.

MICRO-CLIMATE STUDIES

Title: Micro-climate and the Growth of Several Pasture Species (With Vermont).

Leaders: For the Vermont Agricultural Experiment Station - J. W. Marvin.
For the Pasture Research Laboratory - V. G. Sprague.

Micro-climate Data. From 1943 to 1947, a continuous record was kept of relative humidity, precipitation, light intensity, soils moisture at three, nine, and eighteen inches, air temperature at six feet and three inches and soil temperature at soil surface and three inches below the surface.

Species Tests. One hundred plots were seeded without a companion crop in 1943. The seedings, legume-grass mixtures were combinations of Ladino clover, red clover, sweet clover, alfalfa and birdsfoot trefoil, with various grasses including reed canary, timothy, orchard grass and bromegrass. The fertilizer treatments and the yields for 1944, 1945, and 1946 are reported in the eighth, ninth, and tenth Annual Reports.

Table 1 contains a summary of the yields for the three years following the year of seeding.

Table 1. Relative production of various grass and legume species grown in association at Burlington, Vermont.

Species	Yields in pounds dry matter per acre*			
	1944	1945	1946	Total
		LEGUMES		
Alfalfa	4413	3199	2693	10,304
Red clover	3546	3102	2295	8,943
Ladino clover	2850	3307	2608	8,765
Lotus	2236	2960	2524	7,719
Sweet clover	1927	2488	2178	6,593
		GRASSES		
Orchard grass	3059	3100	2144	8,303
Bromegrass	2985	3153	2804	8,942
Reed Canary grass	3128	3291	2749	9,168
Timothy	2785	2939	2670	8,394
No grass	3014	2573	1931	7,518

*Average yield of all plots (including 4 replications) in which each species appeared. One grass was seeded with 1 legume in all possible combinations.

Under the conditions of this experiment conducted on a moderately heavy clay soil and with considerable moisture, alfalfa was the highest yielding legume followed by red clover and Ladino clover. Reed canary grass and bromegrass were the highest yielding grasses, although the effects of the various grass species in a mixture were of minor importance when compared to the influence of various legumes. Sweet clover, a biennial, persisted only the year following seeding, red clover persisted two years as did also the Ladino clover. The type of management, i.e., for hay, may have accounted in part for the loss of Ladino clover at the end of the 1945 season. At the conclusion of the experiment there was a better stand of Lotus than of any other legume.

The six highest yielding mixtures for the three years included alfalfa-reed canary grass, first; alfalfa-bromegrass, second; Ladino clover-reed canary grass, third; red clover-orchard grass, fourth; alfalfa-orchard grass, fifth; and Ladino clover-bromegrass, sixth. The plots reverted to grass and weeds and, following the 1946 harvest, were discontinued.

NUTRITION STUDIES

Title: Measurement of the Nutritive Value of Pastures and of Pasture Plants (With Pennsylvania).

Leaders: For the Pennsylvania Agricultural Experiment Station - R. V. Swift and J. K. Thornton.
For the Pasture Research Laboratory - J. T. Sullivan and V. G. Sprague.

Owing to the lack of proper drying facilities no digestion trials could be conducted during 1947. All grass species, however, were harvested and fertilized to maintain good stands.

Since both the alfalfa and Ladino clover series were becoming contaminated with other species, re-establishment of these two species is in progress and the series should be available for use in 1948 and 1949.

CHEMICAL COMPOSITION

Title: The Chemical Compsotion of Pasture Grasses (With New Hampshire).

Leaders: For the New Hampshire Agricultural Experiment Station - T. G. Phillips and T. O. Smith.
For the Pasture Research Laboratory - J. T. Sullivan.

Statistical studies of the results obtained in connection with the project "The Carbohydrates of Pasture and Hay Crops as Related to Their Utilization by Cattle," are nearly finished.

A new project has been begun, "The Carbohydrates of Pasture Grasses." Pure stands of eight grass species, brome, reed canary, red top, fescue, orchard grass, timothy, tall oat grass, and Kentucky bluegrass have been established in quadruplicate small plots. It is planned to follow carbohydrate changes during growth and maturation and to make species comparisons

in the carbohydrate and other fractions. Exploratory samples were taken in the spring of 1947 and have been analyzed at the New Hampshire Station for total-soluble solids and protein. The average protein content of grass cut at a stage suitable for silage was 12.1 in alta fescue, 9.4 in timothy, and 16.5 per cent in reed canary. The protein content at a stage suitable for hay was 11.3 in alta fescue, 7.5 in timothy, 12.1 in reed canary, and 12.7 per cent in Kentucky bluegrass. Reed canary at a later hay stage averaged 11.2 per cent. At a stage suitable for either hay or silage, orchard grass averaged 13.0 per cent protein and tall oat grass 12.4 per cent.

PASTURE MANAGEMENT EXPERIMENTS

Title: Evaluation of Grasses and Legumes for Hay, Grass Silage and Pasture for Dairy Cattle (With Pennsylvania).

Leaders: For the Pennsylvania Agricultural Experiment Station - C. B. Knodt, P. S. Williams and A. L. Haskins.
For the Pasture Research Laboratory - V. G. Sprague.

Systems of Grazing Management on Orchard Grass-Ladino Clover.

The paddocks of orchard grass - Ladino clover on which various grazing management treatments were started in 1945 (1945 Annual Report, page 18 and 1946 Annual Report, pages 15 and 16) were continued in 1947. While there was a limited amount of killing of the Ladino clover during the winter of 1946-47, it was not so severe as during the winter of 1945-46 and did not appear to be directly due to Sclerotinia as in the previous season. Lack of adequate snow cover and cold drying winds during January and February may have contributed to the injury. While Ladino clover constituted only from 3 to 5% of the dry weight of the herbage present at the time of the first grazing in the spring, it made up from 6 to 20% of the dry weight of the herbage on the paddocks during midsummer. The greatest amounts of clover were present on those paddocks on which early grazing was practiced.

Yields of fat corrected milk (FCM) and total digestible nutrients (TDN) from all paddocks, Tables 2 and 3, were lower in 1947 than in the previous years. This may have been related in part to a shorter grazing season, grazing starting four weeks later in 1947 than in 1945 because of a cool wet spring. Further, the rainfall during the 1947 growing season (April 1 to September 30) was about four inches below the 50-year average whereas for both 1945 and 1946, it was about four inches above the 50-year average. In 1947 the dry periods occurred during the latter part of June, the middle of July, most of August and nearly all of September.

Table 2 Production of milk and silage from an orchard grass-Ladino clover association under different grazing management treatment systems.

Treatment	Pounds per acre, FCM from grazing			Tons per acre, silage 30% DM		
	1945	1946	1947	1945	1946	1947
Early spring / rotational grazing	10,511	8,982	6,524	-	-	-
Deferred spring / rotational grazing	11,457	9,761	7,295	-	-	-
Early spring grazing / silage / rotational grazing	5,272	6,471	5,265	2.8	1.8	1.1
Silage / rotational grazing	7,199	4,529	3,585	3.0	5.2	2.8
Continuous grazing	10,668	9,537	6,993	-	-	-
Kentucky bluegrass	9,135	6,157	3,933	-	-	-

Table 3 Production of total digestible nutrients from an orchard grass-Ladino clover association under different grazing management treatment systems.*

Treatment	Pounds per acre TDN		
	1945	1946	1947
Early spring / rotational grazing	2,610	3,204	2,100
Deferred spring / rotational grazing	4,340	3,707	2,217
Early spring / hay / rotational grazing	2,468	3,276	3,031
Silage / rotational grazing	3,269	3,313	2,495
Continuous grazing	2,980	3,356	2,228
Kentucky bluegrass	4,297	3,139	1,853

*TDN calculated according to methods recommended by the Joint Pasture Committee in which FCM, supplementary feed, gains and losses in weight and maintenance requirements of the animals are included.

It will be noted that the results presented as "fat corrected milk" (Table 2) are not, in every case, in agreement with the results of the same experiments reported as "total digestible nutrients." (Table 3)

Evaluation of Several Grass Legume Mixtures for Grass Silage and Aftermath Grazing. The several grass-legume associations (first crop for silage and the aftermath grazed, 1945 Annual Report, page 20, and 1946 Annual Report, pages 16 and 17) were again harvested for silage and the aftermath grazed in 1947. The production from these paddocks, Tables 4 and 5, was slightly lower in 1947 than in 1946, probably owing to the lack of rainfall mentioned above.

Table 4 Production of milk and silage from various grass-legume associations managed for silage plus aftermath grazing.

Treatment	Pounds per acre, FCM from grazing			Tons per acre, silage 30% DM		
	1945	1946	1947	1945	1946	1947
Orchard grass-alfalfa	4,275*	5,956	5,421	5.6	5.8	5.5
Orchard grass-Lad. Clo.	9,634	5,050	4,884	4.7	5.7	4.4
Bromegrass-alfalfa	3,926	5,248	4,759	8.9	6.5	5.6
Bromegrass-Lad. Clo.	6,526	4,780	4,903	6.2	5.2	5.0
Timothy-Lad. Clo.	7,523	4,157	4,964	6.5	5.1	3.9

*One grazing period is not included for lack of suitable milk cows. Thus, the paddocks were grazed by heifers but the gains in weight are not reported here.

Table 5 Production of total digestible nutrients from various grass-legume associations managed for silage plus aftermath grazing.

Grass-legume association	Pounds TDN per acre from aftermath grazing			Pounds per acre TDN from silage		
	1945	1946	1947	1945	1946	1947
Orchard-Alfalfa	4,045	2,379	1,534	2,744	2,434	2,434
Orchard-Ladino	1,372	2,036	2,025	2,260	2,430	1,948
Bromegrass-Alfalfa	1,268	1,462	-65	3,967	2,687	2,880
Bromegrass-Ladino	1,931	1,720	1,862	2,801	2,095	2,201
Timothy-Ladino	1,709	1,523	1,606	3,086	2,139	1,761

As in 1946, the orchard grass-alfalfa association produced the greatest amount of milk per acre and also was about the highest in silage production. By careful management, good stands of alfalfa have been maintained in association with both orchard grass and bromegrass through three grazing seasons. Since an occasional wilt infected plant was observed during August in 1947, the stand may be expected to thin out during the next year or so. Ladino clover predominated on the timothy and bromegrass plots during midsummer and fall. On the orchard grass plots, it was slightly lower than in 1946. The production in terms of milk of the timothy-Ladino clover association in 1947 was higher than would have been expected from the previous performance, the appearance, and the dry matter yields of these plots during the 1947 grazing season. The reason for this discrepancy has not been determined.

It will be noted that the results presented as "fat corrected milk" (Tables 2&4) are not, in every case, in agreement with the results of the same experiments reported as "total digestible nutrients" (Tables 3 & 5). These discrepancies have not all been explained. It would seem that for a comparison of treatments within anyone year, the production of fat corrected milk may provide somewhat better data, but that for a comparison of the results of the different years the TDN may provide more reliable data. There are, however, discrepancies in both methods of measuring the production of these grazing experiments. For example, it would seem impossible for a good field of bromegrass-alfalfa to yield a negative amount of TDN from grazing (Table 5). It appears that this statistic resulted from errors involving gains and losses in weight of the animals. Similar errors may also have occurred in other cases, but to a lesser extent. Production expressed as FCM also may not be a true measure of production from any one treatment. While within any one year the same grain-milk ratio was used for supplemental feeding of all cows and the amount of hay fed was the same for all cows, supplemental feeding was not the same in 1945 as it was in 1946 and 1947. Also, in FCM no allowance can be made for the maintenance requirements of the different animals. As the experiment progresses, various problems of technique are being investigated in an attempt to develop methods of determining more accurately the production of the various treatments and mixtures and to be able better to interpret the results obtained.

PASTURE MANAGEMENT EXPERIMENTS

Title: Evaluation of grasses and legumes for hay, silage and pasture (With Pennsylvania).

Leaders: For the Pennsylvania Agricultural Experiment Station - P. H. Margolf, E. W. Callenbach, and J. K. Thornton.
For the Pasture Research Laboratory - V. G. Sprague.

Experiment 1. Evaluation of an Orchard Grass-Ladino Association for Turkey Pastures Under Two Systems of Grazing Management, Differing in Intensity. The third season of pasturing the orchard grass-Ladino clover areas (1946 Annual Report, pages 17 and 18), differing in intensity of grazing management were again used in 1947. Pasturing began May 26 and continued to November 4. The populations of the areas were 150 and 300 poults respectively. Both areas were grazed rotationally. All equipment, shelters, feeders and waterers were moved daily and each area grazed required approximately three weeks for a rotation.

By means of outdoor hoppers, the poults were fed a turkey growing mash mixture, whole oats, whole wheat, whole corn, oyster shell and grit. After three years of grazing the Ladino clover has almost disappeared from these areas. Orchard grass tends to bunch and, when trampled by the poults, smothers the clover. Owing to less rainfall than in the two previous years, the yield of forage was reduced. However, yields of 1500 to 2500 pounds of air dry forage approximates the amount actually grazed by the turkeys on each 2-acre paddock.

The turkeys were 12 weeks of age when placed on these areas and were removed when 32 weeks old. During that period, it required about 5.7 pounds of feed to produce a pound of gain. Normal growth was obtained from both groups. The average body weights were 23.4 and 23.3 for the males and 12.6 and 12.4 for the females in the low and high intensity grazed areas respectively. Mortality of 7.6 and 6.1 per cent was considered low for grazing these areas the third successive year.

Experiment 2. To Evaluate 6 Species of Grass Grown in Association with Ladino Clover for Preference by Turkeys, Persistence and Productivity. Each of the following species of grass was seeded with Ladino clover on a two-acre area in replicate plots approximately 33' by 50'. These plots were so arranged that the birds had access to at least two replicates of each species for each day while grazing. Three hundred poults were used in this experiment. Feeding and moving of all equipment, shelters, feeders and waterers was similar to that used in Experiment 1. It appears that:

Reed canary provided continuous all season growth of coarse, erect leaves which turkeys eat well. Ladino clover can compete for ground coverage with this species of grass.

Orchard grass bunches, mats and smothers the clover when trampled by the poults.

Brome grass gives too little mid-season growth, but helps provide good ground coverage. Best Ladino clover stands were with bromegrass. Kentucky bluegrass gives poor mid-season growth, especially in seasons of light rainfall, but does provide a good ground coverage. Ladino clover competes well for ground coverage with this grass under this type of grazing.

Tall oat grows vigorously early in the season before the birds are on range and provides little growth during the summer and fall when the birds need an abundance of pasture. Frequent grazing and clipping has killed most of this grass. Ladino clover replaces tall oat grass.

Tall fescue, the sixth species of grass studied, is avoided by the birds until the other grasses have been eaten. The clover is also crowded out when grown with this grass.

Over the entire season, grasses showing best recovery of growth have been reed canary and orchard grass.

Experiment 3. Evaluation of Green Feed Fed as a Supplement to the Ration of Growing Turkeys in Confinement. Four groups of approximately 72 poults each were grown in confinement and fed turkey growing mash, grains, oyster shell and grit. Two of the pens received freshly cut greens consisting principally of Ladino clover, but also including a few weeds and some Kentucky bluegrass. These were chopped and fed daily as a supplement to the ration. It

required 5.7 and 6.4 pounds of feed to produce a pound of gain for the groups with and without green feed respectively.

Approximately ten pounds per poult of mash mixture was saved when poults were given green feed as a supplement to the ration.

PASTURE RENOVATION EXPERIMENTS

Title: Grassland Renovation Trials in Connecticut (With Connecticut).

Leaders: For Storrs Agricultural Experiment Station - B. A. Brown and R. I. Munsell
For the Pasture Research Laboratory - V. G. Sprague.

Accomplishments and Results. The grazed two-acre pasture, heavily disked in the fall of 1942 and seeded to Ladino clover in the spring of 1943 had 3 per cent Ladino clover, but 11 per cent native white clover, in 1947. The yield of this plot as measured by grazing was 1564 pounds of total digestible nutrients per acre, giving it a rank of fourth among seventeen pastures. Most of the feed was supplied by Kentucky bluegrass, which has grown luxuriantly since the renovation practices of 1943.

Birdsfoot trefoil, also seeded in the spring of 1943 on another, but untilled, grazed pasture occupied 2 per cent of the area in September, 1947. The yield of this plot, as measured by grazing, was 1533 pounds of total digestible nutrients, a rank of sixth among seventeen pastures varying from 690 to 1706 pounds of total digestible nutrients per acre.

No herbicides were applied in 1947 in the project where such materials have been used to kill existing vegetation in preparation for seeding Ladino clover without tillage. The plots treated late in 1946 were seeded in March, 1947. Many of the previously treated and seeded plots had excellent stands of Ladino clover in 1947. For example, some plots on which Atlacide at 100 pounds per acre was applied in early December, 1943, and seeded with Ladino clover in March, 1944, averaged 54 per cent Ladino clover in 1947.

PASTURE RENOVATION EXPERIMENTS

Title: Grassland Renovation Experiments in Massachusetts. (With Massachusetts).

Leaders: For the Massachusetts Agricultural Experiment Station - W. G. Colby.
For the Pasture Research Laboratory - V. G. Sprague.

Work in pasture renovation was largely confined to the Tiffany Farm near Easthampton, Massachusetts. About two acres of rough "hummocky" land were prepared for seeding, using a very heavy disc-harrow of "war surplus" origin. Although the machine was not a "cutaway" harrow, because of its huge size and weight, it did a creditable job. A medium sized track laying tractor was used for motive power.

Limited observations were made on the use of a small "disc" plow for tilling rough land. While this implement can be used for this purpose, it is doubtful if it is as efficient or as effective as a heavy disc-harrow, particularly of the "cutaway" type.

An earlier account (1945 Annual Report, page 24) was given describing the difficulties encountered in establishing a grass seeding on a newly renovated pasture. The difficulty was ascribed to poor nodulation of the clovers and to unfavorable weather conditions. This spring a similar situation developed on a large newly cleared tract. Though this land was liberally limed, manured and fertilized, its grass seeding was very poor. In view of the ideal weather for establishing new seedings in this case, there must be some other explanation for the poor growth obtained. Since nodulation here was also very poor, the suggestion is advanced that some of these soils with a high content of raw humus may, for a time at least, be actually "toxic" to the legume bacteria, irrespective of how they are limed and fertilized.

PASTURE RENOVATION EXPERIMENTS

Title: Pasture Renovation Trials in Central Pennsylvania (With Pennsylvania).

Leaders: For the Pennsylvania Agricultural Experiment Station - A. W. Clyde and J. K. Thornton.
For the Pasture Research Laboratory - V. G. Sprague and R. R. Robinson

Seedbed Preparation. This phase of the work was concluded in 1946 and published.

Species Adaptation - 1943 Renovation. Yields from all species and mixtures in 1947 were appreciably below those from 1944-46, inclusive. There may have been several causes for this: (1) the stand was 5 years old and most of the legumes were thinning out; (2) the rainfall during the 1947 growing season was approximately 8 inches below that in 1945 and 1946 and was 5 inches below 1944; and (3) a heavy infestation of field mice killed about 98% of the Ladino clover and seriously injured the alfalfa, orchard grass and bromegrass.

With the thinning of the stand of legumes, this experiment was concluded in the 1947 season.

The data for the five-year period 1943-47, inclusive, are presented in Table 6, the first renovation series seeded March 31, 1943. It is apparent from these data that the differences in yield between the legume species are far greater than the differences between the grasses. As would be expected, yields decreased when the legumes went out, as for example, with red clover which killed out in the winter of 1945 and Ladino clover which went out in late May, 1947. Owing to severe insect injury in the spring of 1944, sweet clover

never did do well. Yield increases on these latter plots in 1945 and 1946 were due to better establishment of the grass and to volunteer white and Ladino clover coming into the plots. Alfalfa exceeded all other legumes in yield each of the five years except during the year of establishment when red clover both alone and in combination with alfalfa and Ladino clover was highest yielding. Plots where Ladino clover was the only legume in association with grass were not so high yielding as those where red clover and alfalfa were also included. Lotus was slow to become established, but yielded well in the third year only to be weakened during the fall and winter of 1945 (probably by disease). It recovered somewhat in 1946 and 1947, so that a fair stand is still present. It did not seem to be bothered particularly by field mice in 1947 when the other legumes were severely damaged.

Table 6 Relative production of various grass and legume species grown in association on a renovated pasture sod. Series seeded March 31, 1943, at State College, Pennsylvania.

Species and Mixtures	Yields in pounds dry matter per acre					
	1943	1944	1945	1946	1947	Total
			LEGUMES*			
Alfalfa	1,897	5,342	7,394	6,734	3,857	25,224
Red clover-alfalfa-Ladino clover	2,425	4,176	5,850	5,088	2,691	20,230
Red clover	2,495	4,062	5,497	2,547	--	14,601
Ladino clover	1,828	3,454	4,509	4,645	2,676	17,112
Lotus	1,026	1,992	5,450	3,199	3,271	14,948
Sweet clover	1,648	1,869	2,831	2,855	--	9,203
			GRASSES**			
Orchard grass	1,676	3,456	5,137	4,960	3,267	18,496
Bromegrass	1,781	3,633	5,911	5,061	3,688	20,074
Timothy	1,600	3,654	5,898	4,628	3,061	18,841
Kentucky bluegrass	1,806	3,903	6,340	4,681	2,646	19,376
Bromegrass-orchard grass-timothy	2,022	4,003	6,324	5,535	3,519	21,403
No grass	1,879	3,796	5,501	4,634	2,561	18,371
Not fertilized-not seeded	818	739	986	671	1,161	4,375
Fertilized-not seeded	1,353	1,042	3,642	3,449	2,753	12,239

* Yields of legumes calculated by averaging all replications of all plots of grass species in which a particular legume occurred.

**Grass yields calculated by averaging all replications of plots of Ladino clover, alfalfa, red clover-alfalfa-Ladino clover and Lotus in which a particular grass occurred.

Of the grasses, the bromegrass-orchard grass-timothy association with various legumes was slightly higher yielding over the 5-year period followed closely by bromegrass with the legumes. The associations of legumes with orchard grass and with no seeded grass were lowest and yielded about the same. In the "no grass" plots, the harvested herbage consisted largely of legumes whereas on the orchard grass plots, the growth of the legumes was inhibited by competition with the orchard grass. The seeding rate of orchard grass in these plots was 10 pounds per acre which was too high because it provided too much competition to the legumes. Those seeded with the bromegrass-orchard grass-timothy mixture were in reality orchard grass seeded at the rate of 3 pounds per acre since neither the bromegrass nor timothy became established. On all grass plots, it was generally observed that as the growth of grass increased, the legumes decreased and similarly with a less aggressive grass, the legumes increased. This may account, in part, for the small differences in production of the various grass species in association with legumes. It should be borne in mind, however, that these plots were harvested whenever the legume was ready without regard to stage of development of the associated grass. This might, in some cases, accentuate differences between legumes and decrease the differences between grasses.

The production of the original sod which was limed and fertilized with P and K did not increase until the third year after which it consisted of white clover and Kentucky bluegrass and remained about constant in production. The original sod, not fertilized or limed, remained low in production and the herbage produced, decreased in quality. After 5 years, the yields consisted almost entirely of hawkweed, cinquefoil, poverty grass and moss so that its grazing value was probably much lower than the dry matter yields would indicate.

Species adaptation, 1944 Renovation. This experiment, located near the 1943 renovation experiment, was seriously infested with field mice during June of 1947. These rodents almost entirely eliminated the Ladino clover and injured the alfalfa, orchard grass and bromegrass. It was thus necessary to conclude the trials with the 1947 season.

The yields of the various species of grasses and legumes seeded on March 31, 1944 on land prepared by disking, liming, and fertilizing in August 1943 are presented in Table 7.

Table 7 Relative production of various grass and legume species grown in association on a renovated pasture sod. Series seeded March 31, 1944 at State College, Pennsylvania.

Species and Mixtures	Yield in pounds dry matter per acre				
	1944	1945	1946	1947	Total
	Legumes tested with Orchard, Tall Oat, Alta Fescue*				
Alf., Lad.	1712	4890	6077	3605	16,284
Red., Lad.	1861	5673	5582	3189	16,305
Red., Alf., Lad.	1989	6063	5620	3371	17,043
Lotus	1442	4575	3933	3076	13,026
Lotus, Sw. Cl.**	1506	3708	4385	2961	12,560
	Legumes tested with Brome, Timothy, Reed Canary*				
Alf., Lad.	1899	4508	6267	3871	16,545
Red., Lad.	1966	5338	4622	2960	14,886
Red., Alf., Lad.	1895	5757	4692	3088	15,432
	Grasses tested with Alf.,Lad.-Red.,Lad.-Red., Alf., Lad. /				
Brome	1633	4663	4744	3116	14,156
Timothy	2331	5584	5417	3509	16,841
Reed Canary	1796	5356	5420	3294	15,866
Orchard	1808	5298	5483	3371	15,960
Tall Oat	2005	5761	5862	3472	17,100
Alta Fescue	1733	5568	5935	3323	16,559
	Grasses tested with Lotus - Lotus & Sw. Cl.** /				
Orchard	1486	3903	3810	2975	12,174
Tall Oat	1659	4285	4409	3072	13,425
Alta Fescue	1276	4236	4259	3008	12,779

**Sw. Cl. present only first two years; thereafter Lotus was the only legume on these plots.

* Yields of legumes calculated by averaging all replications of all plots of the grass species in which the legume occurred.

/ Yields of grasses calculated by averaging all replications of all plots of the legume species in which the grass occurred.

It will be noted that the red clover and Ladino clover association was slightly higher yielding in the year of seeding but thereafter the alfalfa increased in productivity so that in the year after seeding the combination of red clover with alfalfa and Ladino clover was highest yielding. In third and fourth years after seeding when the red clover had largely disappeared and the alfalfa was well established, the alfalfa-Ladino clover combination was the highest yielding. Lotus was the lowest

yielding of the legumes each year. Botanical separations of the herbage indicate this was owing not only to the lower yield of the legume itself but also to the lower yield of the grass in association with the Lotus than of the same grass in association with either red clover, Ladino clover, or alfalfa. Observations indicated this difference did not follow from competition by the legume but possibly from lower supply of nitrogen by Lotus than other legumes for the growth of the associated grass.

This is also evident in the comparison of yields of various species of grass where the same grasses grown with Lotus yielded about 2000 pounds less than when they were grown with the other legumes. Comparing yields of the six species of grass, each grown in combination with red clover and Ladino, with alfalfa and Ladino clover and with red, alfalfa, and Ladino clover, tall oat grass was slightly higher yielding than the other species and bromegrass was slightly lower. This may have been owing in part to the lower yields of bromegrass during the first two years while it was becoming established. All yields were obtained under a management system in which the first crop was removed at the silage stage and the aftermath removed by clipping to simulate an intermittent grazing system.

Time and Rate of Seeding, 1945 Renovation. During 1947, limitations of labor prevented the harvesting of yields from all plots including the various seeding dates, companion crops, treatments, and seeding rates included in this experiment. However, it was possible to obtain yields from all seeding rates and mixtures on the March and May dates of seeding and for the one mixture of alfalfa-Ladino clover-orchard grass, on all seeding dates with and without a companion crop of oats at the time of seeding (1945). From the data obtained in 1947 it is apparent that seeding the alfalfa-Ladino clover-orchard grass mixture in March without a companion crop produced somewhat higher yields than the April or May seeding. Also, when a companion crop was used in the April and May seedings in 1945, the 1947 yields were slightly below those seeded without a companion crop. In the red clover-Ladino clover-orchard grass association March seedings in 1945 resulted in somewhat greater yields in 1947 than did May seedings. There appeared to be little or no difference between the one pound and one-half pound rate of seeding of Ladino clover as reflected in the 1947 yields of the March seeding. It would appear that a seeding rate of three to five pounds per acre of orchard grass seeded with the red clover and Ladino clover is better than the eight pound rate. This time and rate of seeding experiment was concluded with the 1947 results.

PASTURE RENOVATION EXPERIMENTS

Title: Pasture Renovation Trials in Rhode Island (With Rhode Island).

Leaders: For the Rhode Island Agricultural Experiment Station - Irene H. Stuckey.
For the Pasture Research Laboratory - V. G. Sprague.

On the experimental pasture where the Ladino clover suffered severe injury during the winter 1945-46, recovery had taken place to the extent that the yields for the 1947 grazing season were again equal to those obtained in 1945. At this time, there is no evidence as to the extent the recovery of the Ladino clover was governed by grazing management, by fertility or by differences in weather, but all of these are important in maintaining Ladino clover for any extended period.

In the experimental pasture renovated a year later, differences among species were more noticeable in 1947 than in 1946. These results are giving evidence for selecting species to be grown on areas where moisture is likely to be the limiting factor. Ladino clover has persisted and yielded well in these mixtures for the third consecutive year, but whether it would do so during periods of extended drought remains to be seen. Birdsfoot trefoil continued to spread this season and remained green even on the dryest portions of the area during a drought period in September. Orchard grass consistently out-yielded the other grasses and, like the birdsfoot trefoil, continued to grow during dry weather when the other species yielded very little. Tall fescue was as productive as the orchard grass, but this species does not appear to be especially palatable even during rainy weather and in even brief dry periods, the leaves roll and become as stiff and sharp as needles.

PASTURE RENOVATION EXPERIMENTS

Title: Pasture Renovation Trials in Vermont (With Vermont).

Leaders: For Vermont Agricultural Experiment Station - A. R. Midgley and K. E. Varney.
For the Pasture Research Laboratory - V. G. Sprague.

Use of Nitrogen. Considerable fertilizer and lime are needed to establish suitable plants for pasture renovation on poor soils. While the establishment and maintenance of legumes are usually the main problems in pasture renovation, yet grasses are also difficult to establish if adequate nitrogen is not available during the first year. Very good stands of legumes have been established when adequate lime and minerals have been used, but on poor run-down pastures where poverty grass is predominant, some nitrogen is necessary for good grass establishment. Such soils are frequently so low in available nitrogen that seeded grasses are difficult to establish, and without a proper grass association legumes frequently suffer from excessive winterkilling. Of course, the legumes will finally supply adequate nitrogen, but on poor nitrogen-deficient soils this is frequently too late for good stands of grasses like brome and timothy. On such soils, the Vermont Station recommends the use of a 1-2-2 fertilizer ratio, supplying about 30 pounds of nitrogen.

Pasture land that is already quite productive or contains a bluegrass-clover level of fertility should receive only minerals and lime because on such soils there is usually adequate nitrogen for grass establishment. Under such conditions, the use of nitrogen may be detrimental because the sod forming grasses may be stimulated to such an extent that they become detrimental to the seeded legumes. This occurs particularly if the old sod is not completely killed before reseeding.

Time of seeding. Nature allows most forage crop plants to ripen and drop their seeds in late summer or early fall. Good stands of grasses and legumes are frequently obtained by this method because "nature" makes a very heavy seeding rate and allows for a high mortality. It has been found that nature's way is an extravagant waste of seed as far as most legumes are concerned. Birdsfoot trefoil and alfalfa as well as most of the clovers showed a high mortality when planted so late in the fall that they did not become well established before winter. Planting on frozen ground in early winter was somewhat better, but it seems that even in this case some of the more "permeable" seeds swelled and later died. This date of planting was not as good as an early spring seeding on frozen ground. Planting at this time of the year is recommended on fall prepared land that remains rather wet, late in the spring. Planting on such land would normally have to be delayed until very late in the spring after the ground dried out and machinery could be used. Furthermore, preliminary results indicate that some legumes are better able to compete with weeds when planted very early in the spring, on frozen ground, rather than the customary late spring seeding.

RUNOFF IN PASTURES

Title: Moisture Relations in Pasture and Grassland Soils (With Pennsylvania and the Research Division, Soil Concervation Service).

Leaders: For the Pennsylvania Agricultural Experiment Station and the Soil Concervation Service - R. B. Alderfer.
For the Pasture Research Laboratory - R. R. Robinson.

Soils from which runoff was determined by the rainfall simulator technique (1946 Annual Report, page 24) were analyzed for volume, weight, moisture content, capillary and noncapillary porosity, pH, organic matter and mechanical analysis. The high rate of runoff from heavily grazed sites was associated with lack of soil cover together with high volume weights and low values for noncapillary and total porosity in the 0-1 inch surface soil layer. Compaction on heavily grazed sites was much greater in the 0-1 inch layer than in the 1-3 inch and 3-6 inch layers, even though the surface layer was much higher in organic matter. The data have been summarized and published.

PART II

RESEARCH AT THE LABORATORY

CYTOGENETICS AND BREEDING

Varietal Improvement in Dactylis glomerata, Poa pratensis, Bromus inermis, and Trifolium repens

Inbreeding in Orchard Grass. During the summer of 1947, selected plants were selfed for continuation of each of the 64 I_2 lines planted in the spring of 1945 (1945 Annual Report, page 36). Because of the pressure of other work, no additional inbred material was planted in the field during this year.

Hybridization and Recombination of Characters in Orchard Grass. From seed obtained during the winter of 1946-47 (1946 Annual Report, page 26) 2600 F_2 plants from 16 crosses were planted in the field in the fall of 1947. In certain other crosses where it was desired to study the inheritance of quantitative characters, such as earliness of maturity, an additional quantity of F_1 seed was needed for setting up the experiment. The appropriate parental clones have been established in the greenhouse and crosses will be made during the winter of 1947-48. In certain of the crosses, results indicated varying degrees of self-fertility among the F_1 plants. These F_1 plants are likewise growing in the greenhouse to be bagged for the production of additional selfed seed. It is contemplated that field plantings will be made in the spring of 1948, using F_1 and F_2 seed obtained in the greenhouse.

Comparison of Clonal and Polycross Progeny Tests for Evaluation of Individual Plants of Dactylis glomerata and Trifolium repens. No yield data were taken during the summer of 1947 from the plots established in 1945 (1945 Annual Report, page 37). Owing to a shortage of field help, only observational data were taken during the summer. From the observational data, it was concluded that there were greater differences in growth habit, leafiness, earliness, and aftermath growth among the orchard grass clones than among their respective polycross progeny. There were, however, significant differences in these characters also among the polycross plots. Data obtained from the Ladino clover plots have already been reported (page 11).

Reaction of Varieties of Dactylis glomerata to Systems of Management and Associated Species. Due to the pressure of other work and inadequacy of field labor, it was impossible to collect additional yield data from the orchard grass variety trials established in 1945 (1945 Annual Report, page 38). These plots were maintained by clipping during the summer of 1947 and observational data were collected from them. These observations indicated differences in maturity date, yield of hay, aftermath growth and compatibility with Ladino clover. The damage by field mice was also extensive in these plots and resulted in almost complete elimination of the Ladino clover stand by the fall of 1947. These plots were clipped late in the fall with the objective of reducing

spring growth of the orchard grass to facilitate the reestablishment of Ladino clover by seeding in the early spring of 1948.

Response of Strains of Kentucky Bluegrass to Nitrogen Fertilization and Height of Clipping. The plots established for study of response of Kentucky bluegrass strains to nitrogen fertilization and height of clipping (1943 Annual Report, page 46; 1945 Annual Report, page 41; 1946 Annual Report, pages 27-28) were continued during the summer of 1947. The plots receiving nitrogen fertilization were clipped six times and those receiving no nitrogen fertilization were clipped five times. Plots which had received nitrogen fertilization contained low percentages of white clover while the no-nitrogen plots showed high percentages of white clover. From the no-nitrogen plots, botanical separations of the harvested herbage were made at three of the five clipping dates. In regard to total yield of herbage from the plots, there were statistically significant differences among strains at each date of clipping both under nitrogen fertilization and without fertilization; the differences between strains were considerably larger on the nitrogen plots. The range in yield for the season on the nitrogen plots was from 5,529 pounds per acre for strain 143(223) to 4,371 pounds per acre for strain 172(14). The no-nitrogen plots ranged from 3,798 pounds per acre for strain 130(36) and 3,714 pounds per acre for 143(223) to 3,165 for strain 172(14). As might be expected from these results, the F values for comparing variance for strains with variance for error were considerably higher in the series receiving nitrogen fertilization than in the no-nitrogen series. The statistical analysis of these data has not been completed, but the results suggest that there was no striking interaction of bluegrass strains with nitrogen fertilization on these plots.

Comparative Behavior of Strains of Kentucky Bluegrass Alone and in Mixtures of Strains. In the experiment designed to evaluate the relative productive capacity of strains of Kentucky bluegrass in mixtures with white clover when seeded alone, with their behavior when seeded as a mixture of two strains, three strains, four strains and five strains (1945 Annual Report, page 41), the plots were harvested six times during the summer of 1947. Botanical separations of the herbage from these plots were made at three of the six clipping dates. The differences between individual strains were statistically significant. There was no very striking advantage, however, of the mixtures of strains over the strains seeded along. Statistical analyses of these data are in progress.

Production of Improved Strains of Bromegrass. From the 173 clones of bromegrass established in a polycross plot with 15 replications in 1945 (1946 Annual Report, page 28), 71 clones were selected during the summer of 1947 on the basis of general vigor, disease resistance, leafiness and other characteristics. These clones were used in the fall of 1947 for the establishment of an advanced polycross block. In this block, 10 replications were used, five plants of each clone being planted in each replication. Seed was harvested from each of the 71 clones during the summer. This seed has been threshed and is available for seeding of plots to provide a polycross progeny test.

Table 8. Total yields of herbage in grams per plot in 1947 from plots of eight varieties of Kentucky bluegrass planted in association with white clover and with and without nitrogen fertilization.

	First Clipping			Second Clipping			Third Clipping			Fourth Clipping			Fifth Clip.	Sixth Clipping					
	No N	N	Total	No N	N	Total	No N	N	Total	No N	N	Total	High N 2"	No N	N	Total	Total No N	Total N	Grand Total
114(12)	232	322	554	154	192	346	234	338	572	142	236	378	213	113	265	378	875	1566	2441
129(193)	205	298	503	140	138	278	240	250	490	168	201	369	186	160	224	384	914	1297	2211
130(136)	232	266	498	180	217	397	266	346	612	186	227	413	202	147	260	407	1010	1518	2528
139(111)	193	235	428	150	172	322	237	292	529	174	214	388	199	157	228	385	911	1340	2251
143(223)	253	342	595	142	165	307	243	337	580	189	248	437	233	161	263	424	988	1588	2576
170(3)	140	161	301	152	133	285	263	282	545	162	227	389	229	189	257	446	906	1289	2195
172(14)	177	224	401	127	156	283	226	297	523	160	193	353	182	150	201	351	840	1253	2093
176(22)	157	175	332	139	195	334	256	368	624	172	192	364	167	132	260	392	856	1357	2213
Total	1589	2023	3612	1184	1368	2552	1965	2510	4475	1353	1738	3091	1611	1209	1958	3167	7300	11208	18508

Isolation of Ladino Clover Plants Resistant to Sclerotinia Trifoliorum. Observations (1946 Annual Report, page 34), suggesting the importance of Sclerotinia trifoliorum in losses of Ladino clover in the field indicated the need for obtaining plants and strains resistant to this pathogen. Development of a technic for inducing infection in the greenhouse (page 38) provided a method of surveying large populations for resistant material.

Plant material used included commercial Ladino clover from various sources, varieties of white clover, 103 Ladino clones in the 1947 polycross test (page 11), two new clones from Canada, 228 Ladino selections made in 1947 (page 11), and polycross seed harvested from five replications of each clone in the 1947 polycross plot. The procedure followed with clonal material involved inoculating five plants of each clone in a preliminary screening test. All clones showing good survival were increased and two replications of five plants each were inoculated. Survivors of this test are being tested in four replications of five plants each. Any clones surviving repeated inoculations of this kind probably are resistant.

For the polycross progeny tests, eighty-four plants of each progeny are being used. Progenies of fourteen clones, selected at random, and forty clones that survived the first inoculation are being transplanted for reinoculation. Survivors of this second test will be increased vegetatively to provide material for a replicated test.

From each of the commercial seed lots of Ladino clover and varieties of white clover, seven replications of forty-two seedlings are being tested.

Genetic Investigations

Heritable Characters in Dactylis glomerata. The search for heritable characters in Dactylis glomerata which will be useful in cytogenetic analysis of this species has been continued and some additional mutant types have been isolated. The studies of F_1 and segregating populations of crosses among mutant types for studies of allelism of the genes conditioning these characters were being conducted by Mr. Dollinger. The data collected by him have not yet been summarized and no further studies of this problem are contemplated until the summaries are completed.

Inheritance of Male Sterility in Dactylis glomerata. During the summer of 1947 approximately 8,600 F_2, F_3 and backcross plants were classified for male sterility. The results obtained were not consistent with the hypothesis advanced previously (1945 Annual Report, page 35), to account for the inheritance of this character. Further cytogenetic investigations will be necessary before conclusive evidence has been obtained.

Inheritance of Immunity from Crown Rust in Diploid Festuca elatior. During the spring of 1947 crosses were made in the greenhouse between plants of diploid Festuca elatior shown previously to be

immune from crown rust (1945 Annual Report, pages 48-49) and certain susceptible plants of this species. F_1 seedlings were started in the greenhouse in the fall of 1947 and subsequently inoculated with crown rust. Plants from crosses of susceptible by susceptible plants were uniformly susceptible. In crosses of immune by susceptible, a few immune F_1 plants were obtained, but a majority were susceptible. The selected F1 plants are being grown to maturity in the greenhouse for use in production of F_2 and backcross seed for further studies of this character.

Inheritance of Flower Color in Medicago sativa. Studies of the inheritance of flower color in alfalfa (1946 Annual Report, page 28), were being conducted by Mr. Dollinger. When he separated from the Laboratory staff, it became necessary to discontinue these studies, at least, temporarily.

Size Inheritance in Trifolium repens. During the winter of 1947, measurement of size characters were made on greenhouse plants set up in the F_2, backcross, and new F_1 studies (1946 Annual Report, page 29). Measurements taken on these plants included length, width, and area of terminal leaflet and width of petiole of the second fully-opened leaf from the tip of the stolon, and diameter and length of the third internode of the stolon. From one to five leaves and stolons per plant were measured.

Ninety-four F_2 clones were self-pollinated in the greenhouse and sixty-six produced sufficient seed for an F_3 progeny test. This test, placed in the field in the spring of 1947, consisted of forty F_3 plants from each of fifty-nine F_2 clones and thirty F_3 plants from each of seven F_2 clones. This material was randomized in four and three replications respectively of ten plants each. Interplanted with this material were the original Ladino and white clover parents, the F_1 clone and each of the sixty-six F_2 clones.

In the fall, leaf measurements--length, width, and area of terminal leaflet--of one to three leaves per plant were made on all surviving F_3 plants and samples of original parental F_1 and F_2 clones. A total of 2,252 plants were studied.

Statistical analyses of these data are now in progress.

Inheritance of Leaf Markings in Trifolium repens. Plants from seed of 240 intercrosses and backcrosses of F1 plants, made in the greenhouse during the winter of 1946 (1946 Annual Report, page 29), were grown and classified during the winter of 1947. In addition, progeny of 100 new crosses between various leaf marking types, and 182 self-fertile plants grown and selfed in the field during the summer of 1945 were classified for leaf marking types.

F1 progenies of crosses involving some of the compound types of markings, i.e., those having two of any of the single types within one leaf, were the principal materials involved in the 1947 greenhouse crossing program. These plants were, in most cases, crossed with the homozygous recessive no marking type and backcrossed to the parents. A total of 220 crosses were made. During the fall of 1947, progenies of 174 such crosses were grown and classified.

Available data are consistent with the hypothesis of a multiple allelic series of seven, or possibly, eight alleles. The relationship of these alleles with the genes conditioning white center leaf, purple leaf, purple mid-rib, and purple splashings on leaf has not yet been determined. Appropriate parental clones for testing this relationship have been started in the greenhouse for use in crosses during the winter of 1947-48.

Cytological Investigations

Origin of Aneuploidy in Dactylis glomerata. Determinations of chromosome numbers of progenies from open-pollinated seed of parental plants which had been irregular in meiosis (1946 Annual Report, page 31) have been completed. Chromosome number was determined from 988 plants in thirteen progenies. Among these, two had twenty-six chromosomes, fifty-three had twenty-seven, fifty-two had twenty-nine, six had thirty, two had thirty-one, and six had forty-two. In addition, five plants had twenty-seven chromosomes plus a centric fragment, and eight had twenty-eight chromosomes plus a centric fragment. There was no striking relation between the percentage of aneuploidy among a plant's progeny and the degree of meiotic irregularity that had been recorded for the plant. In previous investigations of effects of meiotic irregularity in orchard grass, it was concluded that the irregularity contributed significantly to reduction in fertility. The results in this investigation suggest that there was differential elimination of aneuploid gametes to the extent that no consistent relationship could be shown between irregularity and frequency of aneuploidy in the progeny. Elimination of aneuploid gametes would be expressed in terms of decreased fertility. Of the seven chromosomes per genome in orchard grass, two are attached to the nucleolus. As a first step in identifying the chromosome involved in aneuploid plants with twenty-seven and twenty-nine chromosomes, diakinesis is being examined to determine whether the chromosome in question is nucleolar or non-nucleolar. Among twenty-five plants for which these determinations have been made to date, one plant was found to have reciprocal translocations involving the chromosomes in such a manner as to result in a maximum of three rings of eight chromosomes in diakinesis. More detailed studies of chromosome association in this plant are in progress. Among the plants from backcrosses of thirty-five chromosome plants to normal plants with twenty-eight chromosomes, there were found to be six with twenty-eight, twenty-four with twenty-nine, seventeen with thirty, twelve with thirty-one, fifteen with thirty-two, four with thirty-three and one with thirty-four chromosomes. This provides a further range of aneuploid types for the cytogenetic analysis of this species. In a further attempt to identify the extra chromosome in twenty-nine chromosome plants that are available, chromosome numbers have been determined from the progenies of thirty-two crosses of twenty-nine x twenty-nine chromosome plants. Among these progeny plants, certain ones had thirty chromosomes. It may be assumed that, in most cases, one of these two extra chromosomes came from each parent. Therefore, by studies of meiosis in these thirty chromosome plants, it should be possible to determine the homologues of the extra chromosomes involved in the parental twenty-nine chromosome plants.

Effect of Heat Treatment on Meiotic Irregularity in Dactylis glomerata. Studies of the effect of high temperatures and of different durations of temperature treatment on meiotic behavior in orchard grass (1946 Annual Report, page 31), have been completed. The effects of high temperature, as indicated earlier, were increased frequency of univalents, decrease in chiasma frequency, and reduction in average number of quadrivalents at diakinesis and metaphase I. Treatment of the florets with 37° C was effective in producing these results even when the temperature was continued for only two hours. When temperature treatment of 34° was used, considerable effect was obtained at the twenty-four hour duration, a slight effect at eight hour duration, but no effect with shorter periods of treatment. With 31° C there was a slight, but perhaps not significant effect when this temperature was continued for twenty-four hours, but no effect was noted with the shorter treatments. In each case, the degree of meiotic irregularity was considerably less on the fourth day following treatment than it had been on the first day after treatment. Nevertheless, there was indication of significant persistence of the effect into the fourth day in those plants treated at 37° for twenty-four and eight hours and at 34° for twenty-four hours.

Studies on the Origin of Dactylis glomerata. The induced autotetraploids of Dactylis aschersoniana (1946 Annual Report, page 32) were compared on the basis of morphological characteristics with plants of Dactylis glomerata. These autotetraploid plants could be distinguished from related diploid clones only with great difficulty. They did not resemble normal plants of D. glomerata to any greater extent than do diploid plants of D. aschersoniana, indicating that D. glomerata has certain genes that are not found in D. Aschersoniana. In hybridization of D. aschersoniana by D. glomerata, the F_1 plants resembled D. glomerata in all morphological characteristics. They were highly fertile, being more fertile than the D. aschersoniana autotetraploids, both in pollen and seed production. In meiotic behavior, they were similar to plants of D. glomerata in regularity, being more regular than were plants of autotetraploid D. aschersoniana. F_2 populations are being grown in the greenhouse and appear to be normal. In one of these populations two genes were segregating in apparently normal tetrasomic ratios. These were genes conditioning a yellow japonica striping of the leaves and a dwarf habit of growth.

The characteristics by which D. glomerata may be distinguished in general, from D. aschersoniana are found in an accentuated degree in the diploid Dactylis obtained from Iran (1945 Annual Report, page 46). Dactylis specimens in the National Herbarium have been examined and this diploid type resembles specimens that have been classified variously as D. abbreviata, D. hispanica and D. glomerata, var. hispanica. F_1 plants from crosses of this Iran diploid with D. aschersoniana have high pollen and seed fertility and are quite regular in meiosis. Morphologically, the plants resemble normal plants of D. glomerata in every respect, excepting somewhat smaller size. The F_2 population from a cross of the Iran diploid by D. aschersoniana is normal, indicating that there has been no segregation of abnormal or inviable types. The results are consistent with the hypothesis that D. glomerata has originated by chromosome doubling from a hybrid between two diploid types similar

to D. aschersoniana and the Iran diploid. The results indicate further that there has been no differentiation of the chromosomes or development of sterility barriers during the evolution of these types. Thus, on the basis of chromosome pairing and behavior, D. glomerata is an autotetraploid, even though the evidence suggests that the diploid from which D. glomerata arose was a hybrid between two divergent diploid types of the genus. By colchicine treatment of the Iran type, autotetraploid clones have been obtained and attempts are being made to hybridize these autotetraploids with the autotetraploids of D. aschersoniana. If the hypothesis of the origin of D. glomerata is correct, F_1 plants obtained from this cross should represent synthetic D. glomerata. As another approach to this problem, F_1 plants from the cross of the two diploid types have been treated with colchicine and tetraploid sectors have been obtained. When the tetraploid sectors have been segregated by vegetative propagation, they also should be synthetic D. glomerata.

Chromosome Numbers in Bromus inermis. Determinations of chromosome numbers of plants of bromegrass (1946 Annual Report, page 32) have been continued. The chromosome number of 193 plants has been determined. These plants were from 111 seed sources, including six commercial seed lots, eleven collections from natural stands and eighty-eight strains, lines and selections developed at nine experiment stations. One hundred and ninety-two of these plants were found to be octoploid (2n= 56) or approximately octoploid. One plant had eight to eleven chromosome fragments in addition to the normal complement of fifty-six chromosomes.

Hybridization of Lolium perenne by Festuca elatior. Hybrids of diploid meadow fescue with perennial rye grass have been obtained on numerous occasions. No cases have been reported, however, of the tetraploid hybrid between these species. In previous work, autetraploid clones of each of these species have been established following colchicine treatment. Repeated attempts have been made to produce the tetraploid hybrid by crosses between the induced autotraploid of the two species. These attempts have failed in every case, however, because of difficulty in synchronizing the flowering of the two parental tetraploids. The two tetraploids are being grown in the greenhouse during the winter of 1947-48 in further effort to produce this cross. Meanwhile, F_1 plants from crosses of the two diploid species have been obtained and these are being treated with colchicine in an effort to induce chromosome doubling and to produce in that manner the tetraploid hybrid.

Octoploid Ladino Clover. During the winter of 1947, six octoploid Ladino clones provided by Dr. A. Gershoy of the University of Vermont were grown in the greenhouse. These clones were the result of chromosome doubling by colchicine. Three of the clones produced flowers which were used in thirty-nine crosses with normal tetraploid Ladino. Only eight of these crosses produced seed, seven producing one seed each, and one producing five seeds. Intercrosses of the octoploid clones produced from one to seven seeds per flowering head. In the field in the summer of 1947, when surrounded mostly by normal tetraploid Ladino, these three clones produced under open-pollination an average of two seeds per head. These have been planted and the resultant plants will be given cytological and morphological examinatior during 1948.

PATHOLOGY

Studies with Sclerotinia trifoliorum

Pathogenicity. Studies on pathogenicity of the twenty-eight single ascospore isolates obtained during the fall of 1946 (1946 Annual Report, page 34), revealed striking differences. Some isolates were highly pathogenic to Ladino and red clovers while others failed to attack inoculated plants. In general, if an isolate was pathogenic to Ladino clover it was equally pathogenic to red clover.

Preliminary inoculation tests with seedlings of other species of Trifolium indicated that a few were resistant to Sclerotinia; among those showing resistance were T. resupinatum, T. glomeratum, and T. arvense.

Effect of Temperature on Growth and Pathogenicity of Sclerotinia trifoliorum to Ladino Clover. The environmental control chambers were used for this study. Both mature plants and seedlings were tested at the following temperatures: 80°, 70°, 60°, 50°, 44°, 37°, and 32° - 33° F. In all tests single-ascospore isolates from Ladino clover were used. The isolates were classified for pathogenicity on Ladino and red clovers with the following results:

L-SC5-1	Slightly pathogenic
L-SC1-10	Slightly pathogenic
L-SC7-1	Moderately pathogenic
L-SC2-7	Highly pathogenic
L-SC6-5	Highly pathogenic

For each test, plants were grown in 3-inch, glazed pots in the greenhouse until ready to use. They were then inoculated by placing fresh inoculum of the organism in contact with stolons of the plants. The inoculum was prepared from two parts wheat, one part oats soaked in water and then steam-sterilized. The organism was cultured on the grain twenty-one days. Each set of inoculated plants and uninoculated controls was replicated four times and placed at random in the chambers.

In the first test, large plants of Ladino clover were used. Stolons on the plants had developed to the point where the tips reached the periphery of the pot. The plants were inoculated and placed in the chambers at 80°, 70°, and 60° F at a relative humidity of ninety per cent. An additional set of plants was maintained in a chamber at 60° F, with a relative humidity of fifty per cent. The pathogenic isolates usually began to attack plants within four to five days. Notes were taken every other day from the earliest signs of infection until the experiment was completed, approximately twenty-one days later.

None of the controls was damaged by overgrowth of inoculum from adjacent infected pots. At 80° F the most as well as the less pathogenic cultures attacked plants only slightly. At 70°F highly pathogenic cultures attacked the plants early, killing some before the experiment was completed. Slightly pathogenic cultures caused only moderate infection and failed to kill the plants. At 60° F and ninety per cent

relative humidity, the pathogenic isolates attacked plants rapidly and so severely that they were almost dead ten days after inoculation. The slightly pathogenic isolates again caused only moderate damage and failed to kill the plants. At 60° F and fifty per cent relative humidity, the most highly pathogenic cultures failed to kill the plants and in most cases did only moderate damage. The weaker isolates caused only slight damage to plants they attacked. This demonstrated that high humidity favors maximum damage by Sclerotinia trifoliorum.

In a second test, seedlings of Ladino clover were inoculated in the same manner with the same isolates of Sclerotinia trifoliorum. The temperatures ranged from 80° F to 50° F at 10° intervals. The relative humidity was maintained at ninety per cent. At 80° F the pathogenic isolates failed to cause more than a trace of damage. However, at the lower temperatures, the pattern of infection was similar to that described earlier. With seedlings, primary infection was observed three days after inoculation.

A third test was conducted with older plants similar to those used in the first test. Inoculation procedures and isolates were the same. However, the temperature of the chambers was adjusted to 60°, 50°, 44°, and 37° F. An additional set of plants was tested in a cold room at 32-33° F. At each temperature a relative humidity of ninety per cent was maintained insofar as possible.

In general, lower temperatures predisposed plants to more rapid and more severe infection by all isolates. The highly pathogenic cultures attacked plants rapidly and caused severe damage early. Even the less virulent isolates caused moderate to severe damage at the lower temperatures. Plants incubated at 32-33° F were attacked more slowly, but eventually just as severely as those at 50 or 60° F.

Some general observations showed that inoculum killing petioles of plants did not necessarily kill stolons also. Stolon tips and nodal buds appeared to be highly vulnerable to attack by Sclerotinia. The internodes of stolons were less susceptible. Occasionally, an entire plant was attacked and appeared to be killed by the organism. However, a single bud might survive and start a new plant after the inoculum was spent. It was frequently observed that infection by the organism began slowly then increased rapidly to a peak as it attacked susceptible tissues. The severity of infection then decreased as the tissues died and the inoculum was overgrown by saprophytes. If surviving buds then initiated new leaves the plant might outgrow what appeared to be relatively severe attacks. Drying of the soil or inoculum or decrease in humidity checked growth and virulence of Sclerotinia.

Length of Period Required for Recovery of Plants Severely Damaged by Sclerotinia. During the course of inoculation tests with red clover, it was observed that some isolates of Sclerotinia damaged plants severely, but failed to kill them outright. A total of twenty such plants was set aside on a greenhouse bench for observation on rate of recovery. At the end of ten weeks, some of the plants were deemed fully recovered, and an estimate of the amount of growth in terms of the original plant before inoculation was made.

The data are as follows:

11 plants	-	Completely recovered
2 plants		Fair growth
2 plants		Poor growth
5 plants		Dead

This demonstrates that even under optimum conditions as long as ten weeks may be required for many plants to recover fully from an attack by the fungus. Even then, only a little more than one-half the plants fully recover and produce their normal amount of top growth. In the field, where adverse conditions are more likely to occur, the rate of survival and recovery from attacks by the organism is probably much lower.

Inoculum Preparation Technics. Since Sclerotinia isolates grown on wheat-oats mixture provided fresh inoculum that was pathogenic but somewhat inconvenient to apply, studies were initiated to determine whether the grain inoculum could be dried and still retain its pathogenicity. Cultures of Sclerotinia were grown on the grain medium for three weeks. They were then dried over fans at room temperature and tested on red clover plants in the greenhouse. No reduction in virulence of the dried inoculum was observed.

Although the dried inoculum was more convenient to apply, it was still awkward because it was lumpy. The dried grain inoculum was, therefore, ground in a coarse food chopper and then screened to obtain preparations pulverized to different degrees of fineness. Results of inoculating plants with this material demonstrated that inoculum retained by a 40-mesh screen was still virulent, but finer divided inoculum failed to infect plants readily.

A test was also conducted to determine how long dried pulverized inoculum remained viable when stored at room temperature and at 5° C. After twelve months' storage at 5° C the dried inoculum was still as virulent as freshly prepared grain cultures. That stored at room temperature was largely inactivated.

Attempts to infect plants with whole or ground sclerotia have so far proved unsuccessful.

A Red Clover Clone Resistant to Sclerotinia. During the course of inoculation tests with red clover, two plants were found relatively uninjured among a large number inoculated with pathogenic isolates of Sclerotinia. To determine whether plants had escaped infection, they were reinoculated and one failed to survive. The remaining plant was only slightly injured by the second attempt at infection. The survivor was increased by crown divisions during the summer months and reinoculated in the fall with a composite sample of highly pathogenic isolates. None of the inoculated plants was severely injured although control plants were killed in ten days. The resistant clone is being increased for further testing and observation.

Testing Plants for Resistance to Sclerotinia. Since a convenient and effective technic for inoculating plants with Sclerotinia had been worked out, it was necessary to provide a moist chamber in which many plants could be tested simultaneously. A greenhouse bench was fitted with a canopy of Parafilm shower curtain strips. At one end, a humidifier unit was installed that created a fog within the chamber. The humidifier was automatically turned off and on by a time clock so that it operated fifteen minutes out of every hour from 7 AM to 7 PM. This sufficed to maintain a near saturated atmosphere within the chamber when it was filled with plants. The moist chamber has a capacity of twenty-six flats, each 11" x 23". Depending upon numbers of seedlings per flat, 1300 to 2600 seedlings can be inoculated and tested simultaneously. Large scale inoculation tests are at present being conducted with Ladino clover (page 31) and red clover (p. 12).

Virus Diseases of Trifolium Repens

The Ladino clover leaf yellowing virus (1946 Annual Report, page 35) was tested on a large number of hosts and further identified by its host range and physical properties. It is now known that the virus is different from common white clover mosaic, but is probably more closely related to alfalfa mosaic. The symptoms of the virus are such that it is different from any of the known strains of the latter. To date, the virus has been transmitted to more than forty species in seven families. The host range includes other species of Trifolium, several species of Melilotus and Medicago and Pisum sativum, Phaseolus vulgaris, P. lunatus, Soja max, Zinnia elegans, Antirrhinum majus, Capsicum frutescens, Petunia hybrida, Nicotiana tabacum, N. rustica, and Vinca rosea. Virus was recovered from each of these species by sub-inoculation to Bountiful var. of Phaseolus vulgaris. Local lesions develop in forty-eight hours when a solution containing the virus is rubbed over leaves of beans.

Thermal inactivation tests showed the virus was inactivated when exposed for ten minutes to 63° C but not at 62° C. Virus activity was lost beyond a 1:100 dilution in phosphate buffer at pH7.0. The virus was largely inactive after ageing at 18-20° C for forty-eight hours.

To date, the disease has been observed on Ladino clover in these states: Pennsylvania, Maine, Massachusetts, Connecticut, New Jersey, Rhode Island, Indiana and Oregon. An insect vector for the virus is suspected, but has not yet been identified. Certain weed hosts are also suspected as harbors of the virus. A paper on this subject was presented at the 1947 meetings of the American Phytopathological Society at Chicago, Illinois.

Alfalfa Wilt

Continuing the work reported earlier (1945, pp 51-53, and 1946 Annual Report, p. 33) a technic was tested whereby cuttings from healthy alfalfa plants were inoculated immediately by either soaking the cut

end in a broth culture of the bacteria or else by smearing the end of the cutting in bacterial slime from an agar slant. Only terminal cuttings were used and they were rooted in Vermiculite immediately after inoculation.

Of ten cuttings made from each of ninety clones nearly all rooted showing there was no appreciable difference in capacity of terminal cuttings to root when given optimum conditions. The cuttings from susceptible clones were noticeable by their stunted appearance and typical bunchiness characteristic of bacterial wilt symptoms. Infection data agreed favorably with data obtained later when rooted cuttings of the same clones were used in the annual wilt test.

Red Clover Disease Nursery

Surviving plants from several red clover strains seeded in the plots in 1944 were removed to a breeding nursery for further testing. The 1944 plots were then plowed up in preparation for new seedings. A new nursery of twelve strains of red clover was seeded for futher observation.

Urocystis agropyri on Phleum pratense

A trip made in the spring of 1947 through the New England states completed a survey of smutted timothy started in 1944. Among collections of stripe smut of timothy made in 1944, specimens were found near Brandon, Vermont, infected by Urocystis agropyri instead of Ustilago striiformis, the common cause of the disease. In 1946 a second collection of Urocystis agropyri on Phleum pratense was made near Walpole, New Hampshire. No additional specimens of the disease were collected in 1947. Thus, of twenty-six samples of smutted timothy collected in Maine, New Hampshire, Vermont, New York, Connecticut, Massachusetts, New Jersey, West Virginia and Pennsylvania, two were found infected by Urocystis agropyri. This smut apparently occurs infrequently on timothy. However, unless microscopic examinations are made, the similarity in symptoms of the two smuts may result in attributing some cases of infection by Urocystis agropyri to Ustilago striiformis.

PHYSIOLOGY AND COMPOSITION OF PASTURE PLANTS

Photoperiodic Responses of Several Pasture Species

Work was continued on the responses of various forage plants to supplementary light during the winter months in relation to flowering of perennial species (1946 Annual Report, page 38). In one experiment, studies were conducted to determine the responses of tall oat grass, bromegrass, orchard grass and Canada bluegrass to six hours of supplementary light ranging in intensity from 0.5 foot-candle to 128 foot-candles. This light was supplied at the end of the ten-hour winter day length to provide a sixteen-hour day. None of the above species headed at 0.5 foot-candle but there was heading at 1.0 foot-candle and higher intensities. In general, as the intensity of

supplementary light was increased, the number of days from the initiation of the light treatment to flowering decreased. With orchard grass, a greater number of heads were produced at the lower intensities of two, four, eight and sixteen foot-candles than at the two highest intensities of 64 and 128 foot-candles. With bromegrass and Canada bluegrass more heads were produced at intensities of four, eight and sixteen foot-candles than at either the higher or lower intensities. The number of heads of tall oat grass did not vary appreciably with light intensity between two and 128 foot-candles. However, at one foot-candle it produced no heads. The reason for the variation in number of heads was not determined.

Investigations of persistence of the photoperiodic stimulus from supplementary light were conducted using two clones of orchard grass. One clone, OG 20(16), had been shown previously to require a sixteen-hour day to induce heading and the other, OG 48(280), had been shown to require a twelve-hour day or longer to induce flowering. In these studies, the two light treatments consisted of a sixteen-hour day and of one hour at midnight. The interval at which these treatments were applied included (1) every night, (2) every other night, (3) every third night, (4) every fourth night, and (5) every fifth night. When the plants were not under the supplemental light, they received only the natural winter day length of ten to ten and one-half hours. Clone OG 20(16) flowered at all treatments except the one in which it received light only every fifth night, whereas clone OG 48(280) flowered under all treatments. The number of heads produced under the different intervals of darkness did not vary appreciably when the plants flowered at all. However, the number of days required from the initiation of the light treatment to the date of flowering increased from about forty days on the plants that received a sixteen-hour day every night to ninety days on those plants that received supplementary light only every fifth night. In the majority of the treatments those plants that received one hour of light at midnight produced a greater number of heads per plant, but the number of days to flowering was increased.

During the winter of 1946-47 the effects on heading of length of establishment in the greenhouse prior to initiation of light treatments were investigated, using plants started as seedlings from seven species and plants started as clones from six species. Plants were started on August 20, September 16, and October 15 and grown under natural day length until December 5 and January 2 when the two light treatments to induce heading were started. These light treatments were (1) supplemental illumination to provide a sixteen-hour day and (2) normal day length plus one hour of light at midnight. Of the seven species of seedlings used, those started on September 16 and receiving light in December headed as well as those started in August, but produced fewer heads. Those started in October and receiving light in December produced fewer heads and also fewer species headed. Turning the lights on in January increased the numbers of species heading, but the number of heads was reduced. Of nine clones of the six species used, those started in September and receiving light in December headed as well as any and produced a satisfactory

number of heads. Starting the clones in October and turning on the lights in December resulted in good heading, but there were fewer heads from each pot. When the lights were not turned on until January there was an increase in the number of heads. Throughout this experiment there was no appreciable difference between the sixteen-hour day and the one hour at midnight supplementary light treatments.

The Responses of Dactylis glomerata-Trifolium Repens to Nitrogen Fertilization, Soil Moisture, and Clipping Treatments.

Studies were initiated this year to determine the botanical composition, yields, and seasonal distribution of yields, of an orchard grass-Ladino clover sod with two levels of nitrogen, two soil moisture levels and two clipping treatments in all possible combinations. The nitrogen levels are no nitrogen and nitrogen applied after each cutting in an attempt to obtain maximum growth; soil moisture levels are those provided by natural rainfall and rainfall plus irrigation; and clipping treatments are early hay followed by aftermath cuttings and frequent clipping to two inches when eight to ten inches high. All plots are to be maintained at a high level of lime, phosphate and potash.

The area had been seeded in 1944 and this year the stand of clover was rather poor. On the high nitrogen plots, particularly those cut for hay, the herbage was almost pure orchard grass. Irrigated orchard grass made excellent growth during July and August, but recovered slowly during September. Without irrigation, growth during midsummer and fall was poor. Total yields of dry matter ranged from 3148 pounds per acre for the frequently clipped plots receiving no nitrogen or irrigation to 8911 pounds per acre for the hay series receiving high nitrogen and irrigation. Maximum yields without irrigation were 6410 pounds per acre.

Fall vs. Spring Applications of Nitrogen to Dactylis glomerata

Sulfate of ammonia at the rate of thirty pounds of nitrogen per acre was somewhat more effective when applied in the spring than in the fall. This is in agreement with the results reported last year (1946 Annual Report, page 40). At rates of sixty and one hundred twenty pounds of nitrogen, however, any differences in yield due to either time or rate of nitrogen application probably are not statistically significant. Chemical analyses of the herbage have not been completed, but the appearance of the grass at harvest suggested that at the higher rates spring application of nitrogen may have increased the protein content more than fall applications.

Response to Nitrogen Fertilization, Irrigation, and Clipping Treatments on a *Poa pratensis* - *Trifolium repens* sod

The results obtained during the fourth year of this experiment (1944 Annual Report, page 49, 1945 Annual Report, page 56, and 1946 Annual Report, page 41) show marked differences in percentage stands of clover (a mixture of Ladino and white) and in yields of herbage due to nitrogen fertilization and clipping treatment. Irrigation greatly increased yields of herbage during the latter part of the season, but prior to the last week of June rainfall was adequate for optimum growth. Rainfall was considerably less than optimum during July, yet the deficiency was not acute until August. By the end of the first week of August clover was wilting during the day, and gypsum block readings indicated that soil moisture was below the wilting coefficient to a depth of ten inches. Within another week the soil reached the wilting point at twenty inches, which was the maximum depth at which blocks were installed. Light rains during the latter part of August relieved the drought, but by about September 20, the soil was again at the wilting point to a depth of ten inches and in less than a week to a depth of twenty inches. The drought was not broken until the last week of October. A total of 6.3 inches of irrigation was applied between June 23 and October 9.

In general, the irrigated plots contained somewhat less clover during spring and early summer than the non-irrigated plots. The latter part of the season was so dry that comparisons could be made only with difficulty but apparently the clover survived the drought fairly well.

The importance of clipping treatment in determining stands of clover is illustrated by estimates of stand of clover on the non-irrigated plots in July. On plots clipped to two inches when five inches high, the stands of clover averaged forty and five per cent, respectively, for no nitrogen and high nitrogen fertilization (forty pounds of N after each cutting); whereas, plots clipped to one-half inch when four inches averaged seventy-one and forty-nine per cent, respectively, for the two nitrogen levels. Thus, the estimates show more clover on high nitrogen plots clipped to one-half inch than on plots with no nitrogen, but clipped to two inches.

The effect of clipping treatments is reflected in herbage yields as well as in stands of clover, particularly on plots receiving no nitrogen fertilizer. The average yields of dry herbage from plots clipped to two inches were 2909 and 4015 pounds respectively for no nitrogen and high N, as compared with 4234 and 5050 for plots clipped to one-half inch. It should be noted that the yields of plots clipped to one-half inch without nitrogen were higher than of plots that received forty pounds of N after each cutting, but were clipped to two inches.

Clipping to one-half inch when the herbage reaches four inches, however, leaves the ground almost bare for a few days following clipping. With favorable growing conditions, the plants recover

rapidly, but where clipping is followed by hot, dry weather the sod is susceptible to injury and encroachment of weeds. For this reason, clipping to one inch would appear to be more satisfactory than clipping to one-half inch, particularly, where drought is likely to be serious.

A clipping treatment that has been particularly promising in these trials consists of clipping very severely (to one-half inch when three inches high) in the early spring, followed by clipping to one inch when four to five inches in the summer and fall. One advantage of this treatment is that the severe clipping is done at a time when injury from drought is not likely to occur. Thus, it is possible to favor the clover by decreasing competition from the grass at a time when the hazards of drought injury to the sod are at a minimum.

Carbohydrates in Rhizomes and Stubble of *Poa pratensis* as Affected by Nitrogen Fertilization, Irrigation and Clipping Treatments

Rhizomes and stubble from certain plots of Kentucky bluegrass (see page 43) were sampled throughout the season and analyzed for water soluble carbohydrates and for water insoluble carbohydrates, hydrolizable in hydrochloric acid. Total weight of rhizomes at any one sampling ranged from about two hundred to seven hundred pounds per acre depending largely upon nitrogen fertilization, soil moisture, and season of the year. Both nitrogen fertilization and irrigation increased the total rhizomes, whereas the various clipping treatments appeared to have little effect. Under high nitrogen (forty pounds of N after each cutting) and irrigation, total rhizomes averaged six hundred to seven hundred pounds per acre during fall and early spring and about five hundred during late spring and summer.

Soluble carbohydrates in the rhizomes of the high nitrogen, irrigated plots averaged about twenty-five per cent in April, decreased to eighteen to twenty per cent in early May and remained relatively constant, irrespective of clipping treatment until October and then increased to twenty-eight per cent by late November. These values are somewhat lower than were obtained without irrigation or nitrogen fertilizer. Water insoluble carbohydrates, hydrolizable in hydrochloric acid, averaged about seventeen per cent, regardless of season, nitrogen fertilization, or clipping treatment. The changes in composition of rhizomes, however, were small in comparison with those in the stubble.

Water soluble carbohydrates in the stubble from plots receiving high nitrogen fertilization and irrigation and clipped to two inches when five inches, were as follows:

Late November, 1946	38%
May 2, 1947 (first cutting)	13%
May 8, 1947	5%
May 14, 1947 (second cutting)	7%
July & August, 1947	9 to 14%
October, 1947	23 to 32%
Late November, 1947	32%

The variations during July and August were associated with the clipping cycle, the values decreasing following cutting and then increasing until the next cutting. This was true for both the two inch and the one-half inch height of cutting.

Both nitrogen fertilization and irrigation decreased the soluble carbohydrate content of the stubble. On August 8, soluble carbohydrates were as follows:

Control plots (neither nitrogen nor irrigation)	28%
High nitrogen, not irrigated	25%
No nitrogen, irrigated	18%
Both nitrogen and irrigation	11%

Reserve Studies on Grasses

Chemical analyses of orchard grass collected in two greenhouse experiments have been continued but are not complete. Yields have been reported previously (1944 Annual Report, pages 51-54; 1945 Annual Report, pages 62 - 63). Some tentative conclusions may be drawn.

In an aftermath experiment under two levels of nitrogen fertility in which clipping of tops took place every 35 days, a cycle of sugar concentration occurred between periods of clipping. Following clipping, a drop in the reducing sugar and sucrose concentrations occurred in the stubble and roots when these parts were relatively high in sugars but little change occurred when their concentrations were low. These losses were replaced before the next clipping date. In the tops, sugars tended to be high at the end of the growth period. High nitrogen, as compared with low nitrogen fertilization, increased the reducing sugar content of all plant parts nearly 100 per cent but decreased sucrose. Total sugars were increased by the high nitrogen fertilization only at the later stages of a growth cycle.

The addition of the nitrogen fertilizer at the time of clipping or a combination of its effect with that of the clipping itself caused a sudden increase in total nitrogen and in the proportion of the total nitrogen soluble in alcohol in both stubble and roots. Both these quantities decreased gradually until the next clipping date. The high nitrogen fertilization increased the total nitrogen content of all plant parts over those plants receiving less nitrogen but the proportion of nitrogen soluble in alcohol was increased by heavy fertilization only in the stubble and roots, not in the tops. Of the different plant parts the new top growth was always highest in total nitrogen and the roots the lowest but the tops were always lowest in the proportion of nitrogen soluble in alcohol.

In a hay and aftermath experiment nitrogen fertilizer was applied at different times in relation to the date of hay cutting. Up to the time of cutting the hay, reducing sugars and total nitrogen decreased and sucrose increased in all plant parts. After cutting the hay, reducing sugars and sucrose increased with the age of the new top growth (up to 35 days, the duration of the experiment)

but in the stubble and roots they at first decreased and later were replaced. Of the different plant parts, the tops were highest in reducing sugars and the roots were highest in sucrose. Nitrogen fertilizer caused an increase in reducing sugars but had no obvious effect on sucrose.

The total nitrogen content of all plant parts decreased with time (both before and after hay cutting) except for a sharp increase soon after fertilizer application. Total nitrogen was higher in tops than in other plant parts, was higher in fertilized plants, and in those which had received fertilizer most recently. The proportion of nitrogen soluble in alcohol was higher in roots and stubble than in tops and decreased regularly with age in the stubble and roots except for sharp increases soon after the application of fertilizer. The cutting of hay alone did not cause any change in the proportion of soluble nitrogen when fertilizer was not applied at the same time.

Winter Killing of Ladino Clover

To obtain information on the effect of ground cover as winter protection for Ladino clover, two areas were seeded in August 1945; one to Ladino clover in association with orchard grass and the other to Ladino clover alone. Both areas were mulched with straw during the winter of 1945-46 and no serious injury to the young seedlings resulted. During the summer of 1946, the areas were managed to favor the growth of Ladino clover so that in September of that year a good, well established stand of Ladino clover was present.

Four fall clipping treatments were superimposed on each area to measure the effects of defoliation and removal of natural cover on the winter survival of the clover. These included (1) not clipped after August 20, (2) not clipped after Aug. 20 until Nov. 5, (3) clipped September 13 but not thereafter and (4) clipped September 13, October 15 and November 5. Then, superimposed on the clipping treatments were three mulch treatments in which wheat straw was applied November 15 to provide a good cover. The mulching treatments included (1) no mulch (2) mulch to be removed March 12 before growth started and (3) mulch to be removed April 10 after growth has started. All clipping and mulch treatments were on duplicate plots.

The winter of 1946-47 was rather open. The first snow of 6 to 7" on December 20 was followed by rain which left the plots all bare again by December 28. Intermittent light snow and sleet occurred for the next 7 or 8 weeks until February 22 when 10 - 12" of snow fell. This was followed by high winds so that on the plots with little cover no snow remained. On March 2, 9" more of soft snow fell but this was also blown off by high winds except where adequate ground cover held several inches of snow. On March 12 when the first straw mulch was removed, the Ladino clover under the mulch appeared to be uninjured whereas on the adjacent "not mulched" plots many of the Ladino stolons were brown and appeared dead.

On May 19 after spring growth was well under way observational notes were made on all plots. The readings from replicate plots are averaged and presented in Table 9. It is obvious that the Ladino

clover which was not mulched was severely injured and that this injury occurred some time prior to March 12 when the first mulch was removed. It is also evident that orchard grass growing with Ladino clover served as a mulch and reduced the amount of winter killing. The survival readings from those plots which were not mulched suggest that fall clipping of an orchard grass-Ladino association removes winter protection and, therefore, makes the clover more susceptible to winter injury.

Table 9. Effects of fall clipping and straw mulch cover on the winter survival of Ladino clover.*

	Ratings of winter survival; 1 = Excellent; 5 = Very poor			
Fall Cutting Treatment	No Mulch	Mulch Off 3/12	Mulch Off 4/10	Average
		Pure Ladino		
None	4.0	2.5	1.5	2.7
11/5	4.5	3.0	3.0	3.5
9/13	5.0	2.5	2.0	3.2
9/13,10/15,11/5	5.0	2.5	4.0	3.8
Average	4.6	2.6	2.6	
		Orchard-Ladino		
None	2	2.5	3.0	2.5
11/5	3	2.5	3.0	2.8
9/13	2	2.0	2.0	2.0
9/13,10/15,11/5	3	2.5	2.0	2.5
Average	2.5	2.4	2.5	

*Average of duplicate plots.

The orchard-grass Ladino plots were cut on June 4, dry matter yields were obtained and botanical analyses were made (Table 10). It is evident from these data that three fall clippings reduced the yields of these plots the following spring. It is also suggested that fall clipping increased the amount of Ladino clover present the following year in those plots in which artificial mulch protected the Ladino clover from winter injury. Whether this was owing to less competition in the fall so that a better stand of clover was present at that time or to reduced competition of the orchard grass in the spring was not determined. Observations suggested that both factors may have been operating.

Table 10. Effects of clipping an orchard grass-Ladino clover association in the fall of 1946 on the dry matter yields of silage and the per cent by weight of clover harvested June 4, 1947.*

Fall cutting Treatment	No Mulch		Mulch, Off 3/12		Mulch, Off 4/10		Av. Wt./ plot gms.
	Wt. gms/ plot*	% Lad.	Wt. gms/ plot*	% Lad.	Wt. gms/ plot*	% Lad.	
None	584	1.2	607	2.5	507	2.3	566
11/5	405	2.3	474	3.9	497	4.8	459
9/13	379	5.0	452	10.9	423	8.6	418
9/13,10/15,11/5	342	1.4	428	8.8	367	7.3	379
Average	427	2.5	490	6.5	449	5.8	

*Average of duplicate plots

PART III

PASTURE RESEARCH AT STATE STATIONS

STORRS (CONNECTICUT) AGRICULTURAL EXPERIMENT STATION

Title: Alfalfa Experiments.

Leaders: B. A. Brown and R. I. Munsell.

The new series of fertility plots, seeded in August 1946 with the wilt resistant variety of alfalfa, "Buffalo," were harvested twice in 1947 for yields of dry matter and complete analyses of pure alfalfa. To date (February 2, 1948) only the boron analyses are available and these do not show any remarkable features.

In August 1947, fourteen varieties of alfalfa were seeded on quadruplicated 45 x 11 foot plots. The list includes: Atlantic, Ranger (Arizona), Ranger (Montana), Common (Kansas), Common (Dakota), Common (Montana), Common (Oklahoma), Ontario Variegated, Meeker Baltic, Ladak, Cossack, Argentine, French and Buffalo (Kansas).

Title: The Maintenance and Improvement of Pastures.

Leaders: B. A. Brown and R. I. Munsell.

The Effects of Fertilizer Treatments on the Soil, the Flora, and the Production as Measured by Grazing. Another five-year period has elapsed since a summary of this grazing experiment was published. From 1943-47, the so-called optimum minerals plot (3W) (LPK annually) has produced as much pasturage as those receiving minerals every third year and nitrogen at 30 pounds from Uramon every spring. During the last decade, 3W has had more white clover than the plots under regular LP or LPK fertilization for twenty-four years. It would be considered an excellent white clover-bluegrass pasture. Although the five-year period includes the very dry seasons of 1943 and 1944, when all pastures produced only 60 per cent of the normal (ten-year average), 3W has yielded an average of over 1400 pounds of digestible nutrients per acre or the equivalent of a ton of grain. The acre cost of the annual LPK treatment is less than $10.

To learn if the craving for roughage, particularly the leaves of certain bushes, of the dairy heifers grazing on excellent white clover-bluegrass pasture, is due to a deficiency of one or more "minor" elements in the herbage, sub-plots were treated with various combinations of B, Mn, Cu, Zn, Co and Mn in the spring of 1946. During 1946 and 1947, the heifers appeared to show no preferences for any of the treated areas.

Poultry manure (1.39 per cent N) at 2 tons per acre was spread on one of the plots (6N) in March 1947. The relative production of this pasture was not much different the past season from the average of the previous four years and was less than the adjacent pasture which received 30 pounds per acre of N from Uramon.

The Adaptability of Varieties and Species of Grasses and Clovers for Pastures. The management studies of Ladino clover-grass mixtures were continued in 1947, the eighth complete season of this experiment. As previous reports have given complete summaries of this project, no further statements will be made here.

Crops for fall pasture in 1946 (not reported in 1947): The first cutting yields of dry matter from barley were 15 per cent higher from 80 pounds of N per acre than from 40 pounds, but the reverse was true of the second cutting. Repeating the 40 pound application of N after the first mowing had little effect on the size of the second harvest. With oats, all of the three N treatments resulted in practically the same yields.

The N contents of both cereals were raised appreciably by doubling the 40 pound application of fertilizer N, but as the minimum values were equivalent to more than 20 per cent protein in the dry matter, it appears unlikely the feeding value was improved by the extra N.

In the first cutting, barley seeded at 3 bushels per acre yielded 50 per cent more than when seeded at 1.5 bushels, but at the second harvest 30 per cent less. The corresponding values for oats were 60 and 6 per cent.

Two 9-inch cuttings of either barley or oats produced slightly more dry matter than one cutting at 18 inches. In both 1944 and 1945, much higher yields were obtained from one tall than two short cuts. The unusually warm October in 1946 was probably responsible for the divergent results of that year. Under grazing conditions, it is probable there would be less waste if pastured when 8-10 inches high and the quality would undoubtedly be superior to the more mature forage.

The total yields of fall pasturage from these cereals are not large, particularly when one considers the necessary tillage, fertilizing and seeding operations. The three-year average yields of dry matter from barley were:

Two 9-inch cuts - 1100 pounds per acre.
One 18-inch cut - 1700 pounds per acre.

At 25 pounds of dry matter per cow-day, only about 40 days of grazing per acre were available under the two 9-inch cutting system. That amount is half the corresponding value for the limestone-superphosphate treatment on permanent pastures and one-fourth that from Ladino clover-grass mixtures. Nevertheless, the difficulty of providing fall pasture may justify the use of August seeded cereals.

Causes of Fluctuations in the Prevalence of White Clover. The results in 1947 were very similar to those noted in previous reports.

MARYLAND AGRICULTURAL EXPERIMENT STATION

Title: Pasture Renovation Studies.

Leaders: A. O. Kuhn and S. P. Stabler.

This project was begun in the spring of 1947. The principal objectives are: (1) To compare various seeding mixtures for use in pasture renovation and (2) to compare plowing and disking as methods for preparing old sods for seeding. Results are to be measured in terms of botanical composition of the stands and yields as determined by clipping.

In March, 1947, a Kentucky bluegrass sod, located on the Plant Research Farm near College Park, was prepared for seeding by plowing followed by the usual seed bed preparation; and an adjacent area was prepared by disking. Duplicate seedings of the following mixtures were made: Orchard grass and Korean lespedeza; orchard grass, Kenland red clover, and Ladino clover; orchard grass and Ladino clover; orchard grass and broad leaf birdsfoot trefoil, tall fescue and Ladino clover; Lincoln bromegrass, Ladino clover, and Atlantic alfalfa; timothy and Korean lespedeza; and timothy, Kenland red clover, and Ladino clover. Stand counts made in August indicated that the stands were adequate.

Title: Orchard Grass and Bromegrass for Forage with Legumes.

Leaders: A. O. Kuhn and S. P. Stabler.

This project was begun in the fall of 1947. The principal objectives are: (1) To compare orchard grass and Lincoln bromegrass in mixture with legumes for production of pasture for beef cattle. (2) To compare orchard grass, tall oat grass, tall fescue, timothy, and various strains of bromegrass in mixture with alfalfa for production of hay. (3) To compare these same grasses in mixture with Ladino clover for production of hay and pasturage.

Triplicate plots of 0.7 acre each were seeded in late August of 1947 to compare orchard grass in mixture with alfalfa, red clover, and Ladino clover to Lincoln bromegrass with these same legumes. Results will be measured in terms of beef cattle gains and clipping yields.

Title: Alfalfa Variety Test.

Leaders: A. O. Kuhn and J. W. Magruder

August seedings were made in 1947 at six locations in the state with three replications at each location of the following varieties in pure stand: Kansas common, Buffalo, Atlantic, Ranger, Williamsburg, and Grimm.

Dry matter yields are to be taken and observations made as to winter hardiness and wilt resistance.

NEW JERSEY AGRICULTURAL EXPERIMENT STATION

Title: Belle Ellen Pasture Experiment

Leaders: C. B. Bender and Claude Eby

A report covering the years 1939-1947 on:

Renovating Pastures by Broadcasting Ladino Clover without Preparing the Ground.

Belle Ellen Pasture #14 - 3.3 acres.

The first Ladino seeded in New Jersey on a 3/4 acre plot occurred in the Spring of 1937. Seed bed was prepared and seeded to 1½ bu. oats, 4 pounds Ladino Clover, 6 pounds timothy, and 2 pounds medium red clover. The remainder of this 3 acre field was seeded to 8 pounds alfalfa, 6 pounds timothy, and 2 pounds of medium red clover. The alfalfa and red clover were quickly grazed out of this area, leaving a very open sod. On April 17, 1939, one pound of Ladino clover was seeded broadcast just before a light rain. Excellent germination prevailed and in 1947 both plots in the field contained 65 per cent Ladino clover.

Belle Ellen Pasture #13 - 3.9 acres.

In 1940 one pound of Ladino clover was seeded on a heavy bluegrass pasture containing 58% Kentucky bluegrass and 21% native white clover in late March. This broadcast seeding was followed by an application of cow manure at the rate of 5 tons per acre. Herbage analysis shows that for the last three years 1945-1947 inclusive, the botanical content of Kentucky bluegrass has been reduced to 34 per cent and combined percentage of native white clover and Ladino has increased to 56 per cent.

Belle Ellen Pasture #15 - 3.4 acres.

This pasture was also seeded in late March, 1940, by broadcasting one pound of Ladino clover, with no manure treatment. The Kentucky bluegrass decreased during the period from 46 per cent to 39 per cent and the native white and Ladino clover increased from 25 per cent to 54 per cent.

Belle Ellen Pasture #8 and #9 were seeded to one pound of Ladino clover on April 1, 1947. While no count was made in the fall, it was estimated each of these pastures contained 37 per cent of white and Ladino clovers. The yield of white clover for the previous 5 years had been 26 per cent.

These trials were conducted on heavy loam and stony loam soils of the Dutchess series, where lack of moisture is a factor in extremely dry years. It is noted that during the drouth of 1939, yield of Ladino clover was reduced and many runners on the plants dried up. However, the parent plants set enough seed so that in

the spring and summer of 1940, many thousands of young seedlings emerged to reestablish the stands. Production was curtailed during the drouth of this year and the succeeding years of 1943-1944, but the stand came back by natural reestablishment even stronger than originally. Management necessarily plays an important part in handling the Ladino clover pasture crop.

Title: Alfalfa Variety Test

Leaders: C. S. Garrison, C. B. Bender, and Claude Eby.

Black stem and leaf spot infested all varieties in the plots reducing the second growth to such an extent that no samples were taken.

Dry matter yields of first cutting are as follows for each variety:

Atlantic	2,625 lbs.
Ranger	3,082 lbs.
Buffalo	2,381 lbs.
Oklahoma	1,907 lbs.
Northern Common	2,577 lbs.
Kansas Common	2,234 lbs.

Title: All Roughage and Pasture Feeding Experiments with Dairy Cattle.

Leaders: C. B. Bender and M. A. Sprague.

A study is underway to determine the maximum use which can be made of the more economical feeds, hay silage and pasture in the production of milk. As productive pastures as possible have been established and these are supplemented as feed for 3 different lots of animals with silage, hay and in 2 cases, grain rations.

Five, four acre, pastures were established during 1945 and 1946 (1946 Annual Report, page 53) and are maintained at a uniformly high level of fertility through the liberal use of lime and 600-700 pounds of a 7-7-7 fertilizer annually. One of these pastures was kept in a Kentucky bluegrass-white clover sod. The other four were seeded to Ladino clover, one with bromegrass and one with tall oat grass in August 1945, and one with orchard grass and one with reed canary grass in August 1946. An excellent stand of Ladino clover and grasses was obtained on all areas. The August seeding of reed canary grass came up thin in the fall, but was thickened up with an over seeding on frozen ground in the spring of 1947.

Three lots of cattle have been carried since November 1, 1946 on feed as follows: (1) Exclusively U. S. No. 1 alfalfa hay plus silage (2) hay and silage plus one pound of grain per six pounds of milk produced and (3) hay and silage plus one pound of grain per three pounds of milk produced. All three lots of 10 animals each were grazed together rotating from pasture 1 to 5 from May 3 to September 24, 1947.

In 1947, the first grazing season, the orchard grass-Ladino clover and the reed canary-Ladino clover pastures of necessity had the first crop cut for hay the last of May. In addition the reed canary-Ladino clover pasture was grazed from July 1 until August 10, by only three cows on digestion trials. From then until September 24 it was grazed in rotation with the other pastures by the three lots of experimental cows. The total yields of dry forage produced during 1947 by each of the five mixtures were as follows:

Bromegrass - Ladino clover Ky Bluegrass-White clover	6555 lbs.
Reed Canary grass-Ladino clover	5321 lbs.
Tall Oat grass - Ladino clover	4585 lbs.
Orchard grass - Ladino clover	7269 lbs.

Title: Grasses and Legumes for Poultry Range.

Leaders: M. A. Sprague and C. S. Platt.

The study in the use of bluegrass, ryegrass and Ladino clover for poultry ranges was continued during 1947. The only change in the trials (1945 Annual Report, Page 90) consisted of mowing on June 3 one of the two plots sown to each ryegrass and Ladino clover. Eight hundred birds per acre were placed on the ranges on May 8 and rotated weekly between 2 pens.

Again Ladino clover was outstanding in its use for poultry range purposes. Not only did it persist and continue to recover and stay green throughout the summer and even into the fall period when the aging birds were consuming larger quantities and had essentially killed out the ryegrass and bluegrass, but also healthier birds were obtained at a lower cost of total feed per bird than with any other range or in confinement.

Mowing the first crop in early June reduced the available forage and correspondingly increased the feed consumed. The total cost of feed per bird was least ($.87) on the Ladino clover range not mowed early in the season and greatest for the birds in confinement ($1.08). Ryegrass mowed ($.998), Ladino clover mowed ($.95), bluegrass not mowed ($.93) and ryegrass not mowed ($.92) ranged intermediate.

The production of eggs by the 1946 birds raised on these different ranges was determined from October 6, 1946 to March 1, 1947. More eggs per individual (75) were produced by birds raised to maturity on Ladino clover range than by birds raised on ryegrass (67) or bluegrass (69) with no appreciable difference in mortality.

Title: Supplemental Irrigation on Pasture.

Leaders: S. J. Richards, C. S. Garrison, E. R. Purvis, M. A. Sprague and N. A. Willits.

The object of this study is to investigate the advisability of using supplemental irrigation on improved pastures. The major

part of the experiment is being conducted on an 8-acre pasture at Riverside. The field was seeded in the fall of 1946 to alfalfa, Ladino clover, orchard grass and bromegrass. A fence divides the area so that the irrigated and unirrigated halves may be grazed separately. Three different fertilizer ratios (0-10-10, 5-10-10, and 5-10-20) are applied at the rate of 750 lbs/A annually to plots replicated three times on each half of the field. Clippings under cages are being taken to measure the effects of fertilizer and to supplement the data on grazing days provided.

The rainfall during the 1947 season was such that very little additional yield was obtained from the three one-inch irrigation applications. During the 16-day period between grazings in August, 710 lbs/A (20% moisture) of forage was produced on the irrigated part compared with 320 on the unirrigated. The total yield for the summer was over five tons. No effects of the fertilizer ratios were measurable.

Three demonstration projects of supplemental irrigation on pastures were located on dairy farms in Burlington, Hunterdon and Sussex Counties. In Sussex County supplemental irrigation during the period July 30, 1947 to September 6, 1947 produced additional yields of forage from Ladino clover-orchard grass pasture. The irrigated areas produced 2,228 lbs. of air dried forage during this period as compared with 624 lbs. from the area receiving no irrigation water. The cooperator in Hunterdon County reported that supplemental irrigation on a Ladino clover-timothy hay-pasture combination provided two additional grazings during July and August over the non-irrigated.

These projects were started in 1947. Plans are underway to continue these trials for another three or four years in order to determine the value of supplemental irrigation on pastures under New Jersey's climatic conditions.

Title: Small Grains for Fall and Spring Pasture.

Leader: M. A. Sprague.

Trials are being undertaken to determine the use of small grains for fall and spring pasture with the following main objectives: (1) To determine date of seeding for best growth (2) Type of grain best suited for grazing under New Jersey conditions with respect to yield of forage, winter survival and performance on different soils and fertilizer levels and (3) To determine the effects of fall and spring grazing upon the subsequent yields of grain of the several grains.

No conclusions have been reached as yet but preliminary data gathered during the 1945-46 season indicate that oats do not possess sufficient winter hardiness to warrant use for grazing at this latitude, almost a complete kill being observed where the oats were grazed in the fall of the year. Two varieties of rye each yielded almost twice the dry forage that wheat and barley did during both fall and spring and were ready for grazing at least 10 days earlier in April.

Title: Pasture, Hay, and Silage Crops for the Production of Beef in New Jersey.

Leaders: W. A. Ljungdahl and M. A. Sprague.

This is a new project being undertaken with the following objectives: (1) To determine the relative merits of different grass - legume pasture mixtures for the production of beef. (2) To outline and test a winter feeding program for steer calves and determine the extent to which grass silage, hay, and winter grain pastures can be utilized as a maintenance feed, and (3) to determine the value of Sudan grass and soybeans as a supplementary pasture for boosting midsummer beef gains.

In accordance with the last of these objectives listed, three 4.6 acre pastures were sown with soybeans and Sudan grass during June 1947. The first of these had obtained a height of about 18 inches and was ready for grazing on July 10. Eighteen grade Herefords consisting of both heifers and steers averaging 558 pounds each were purchased on May 3, 1947, and grazed together on an orchard grass, bluegrass and white clover pasture throughout May and June (during which 67 days each animal made 70 pounds of gain in weight or approximately 1 pound per day.) On July 10, the group was split into 2 uniform lots of 9 animals each and one lot remained on two orchard grass and bluegrass pastures and the other lot moved to two equal acreages of soybeans and Sudan grass. From that date until August 21 the animals on orchard grass and bluegrass made an average gain of 0.09 pound per animal per day while those grazed alternately on 2 pastures of the Sudan grass and soybeans gained an average of 1.13 pounds per animal per day. Two separate grazings were obtained from the soybeans and Sudan grass pastures, 1103 pounds of dry forage per acre were consumed in the first grazing of pasture 1 and 1033 in the second after 17 days of recovery. The orchard grass-bluegrass pasture produced less than 1/2 as much dry forage during the same period; this was adequate to meet the maintenance requirements of the cattle but not sufficient to encourage an appreciable gain in weight.

Title: The Utilization of Pastures in the Production of Pork.

Leaders: M. A. Sprague and George W. VanderNoot.

This is a new project with trials located at the College Farm and at the Bordentown Prison Farm, Bordentown, N. J. The main objectives of the investigation include (1) The amount of pork which can be produced from an acre of good pasture (2) The extent to which pasture can supplement concentrate feeds in the diet of hogs and (3) The relative merits of different pasture mixtures for use with hogs.

At the College, two 1/2 acre pastures have been seeded to each of three mixtures, namely: alfalfa, Ladino clover-bromegrass, and Ladino clover-reed canary grass. These and two pastures each of soybeans and rape will be grazed during 1948. At the prison farm

two 3 acre pastures have been sown each to Alfalfa bromegrass-alfalfa and bromegrass-Ladino clover. Additional seedings will be made as occasion permits to orchard grass and other grasses. Grazing will commence in the spring of 1948.

Title: A Study of the Response of Permanent Pasture Sods to Fertilization in New Jersey.

Leader: E. R. Purvis

These studies involve a comparison of the yields from plots receiving no fertilizer with others receiving 500, 1000, and 2000 pounds per acre of a 5-10-10 mixture. Plots are located throughout the state on 3 soil types. Data collected during the 1946 and 1947 seasons indicate that only the 500 pounds per acre application has been profitable.

The influence of nitrogen upon yield and botanical composition is being studied on two soil types in other locations. Results from one year indicate that where nitrogen is increased above a 1-2-2 ratio that the growth of legumes is greatly retarded.

All the pastures involved in these studies consist of mixtures of bluegrass and Ladino clover with some brome or orchard grass present at 3 of the locations.

CORNELL UNIVERSITY (NEW YORK) AGRICULTURAL EXPERIMENT STATION

Title: Breeding and Cytogenetic Investigations with the Forage Plants of New York.

Leaders: S. S. Atwood and R. F. Murphy.

The red clover plants selected in September of 1946 from plots seeded in 1944 were held over the winter of 1946-47 in the greenhouse. About forty per cent of these survived until July, 1947, and were transplanted to the field in order to determine their survival during the winter of 1947-48. In the greenhouse it was noted that most of the surviving plants were infected with virus and/or mildew. They will be examined particularly for perennial habit of growth.

The replicated I_1 inbred progenies of selected plants of bromegrass were noted carefully in their first harvest year, 1947, for vigor of early spring growth, hay growth and aftermath growth; for disease reaction (brown spot and other leaf spots); for lodging resistance; and for uniformity. In general a marked reduction in vigor was noted, as compared to the Fischer strain as check. Many progenies were highly susceptible to foliar diseases and to root rots. Of much interest, however, were a few progenies which were equal to the check for hay vigor, superior for aftermath vigor and disease resistance, and somewhat more uniform for type. Further selfing and selection within and among selected progenies was practiced in 1947. Replicated progenies of these selected I_1 plants will be transplanted to the field in the spring of 1948. A few of the superior I_1 families may be transplanted to isolated plots for seed increase for testing as possible superior varieties.

Of the 192 self-sterile brome plants which were planted in 12 replications of individually spaced plants in a nursery for the evaluation of the clones and for production of polycross seed, 42 were discarded before pollination on the basis of disease reaction. Polycross seed of each of the 150 remaining clones was harvested, and the progeny test will be made for about 100, the others being discarded on the basis of the performance of the clone in regard to such characters as low yield and high incidence of foliar diseases in the aftermath growth. The 150 clones which remained at the time of pollination were taken by the Pasture Laboratory for planting in a replicated spaced plant nursery at State College, Pennsylvania.

Two hundred and forty clones were selected from the 1944 space-planted source nursery of bromegrass instead of 200 as stated previously (1946 Annual Report, Page 57). These clones were planted in 10 replications of individually spaced-plants for the evaluation of the clones and for the production of polycross seed in 1948. In addition 173 clones of bromegrass selected by the Pasture Laboratory were planted in a similar way for the production of polycross seed.

The one-year inbred progenies of timothy were disappointing from the standpoint of vigor and disease resistance and only a few notes were taken in 1947. They will be studied again in 1948. No selections were made. The performance of the 82 clones of timothy planted in the replicated spaced-plant nursery for polycross seed production was also disappointing. Many of the late flowering clones failed to produce seed. The varieties and strains of timothy that are being tested in yield trials will be resampled for superior plants before the progeny testing of the above plants is continued.

The small number of one-year inbred progenies of tall oat grass showed some desirable individual plants but none of the progenies were uniformly superior to the check strain. Selection and selfing was practiced in these progenies in 1947 and it is planned to start an I_2 nursery in 1948.

Two hundred and eighty-four selected clones of orchard grass were obtained from the Pasture Laboratory in 1947. By use of cuttings these clones were established in 8 replications of individually spaced plants for the evaluation of the clones under environmental conditions at Ithaca and for the production of polycross seed. Marked differences in leaf rust reaction were noted during their first year's growth.

Notes on vigor and diseases were taken on the space-planted source nurseries of timothy, reed canary grass, meadow or tall fescue, and tall oat grass which were started at Tully in 1946. In addition a few additional sources of seed of tall oat grass, tall fescue and reed canary grass were started in 1947. The description of these source nurseries was given last year (1946 Annual Report, page 57). Much information on the variability within a variety or strain is obtained from these plantings which is difficult to observe in a solid-seeded plot grown for hay and aftermath production. Some of the plants within the strains and collections of reed canary grass

seem very promising. Some of the timothy varieties had very desirable plants. A few late flowering plants in the collections of tall oat grass seem to be promising. The plants of meadow and tall fescue seem the least promising of all of this new material.

The superior plants of the source nursery of reed canary grass will probably be planted in 1948 in a replicated spaced-plant nursery for evaluation of the clone and for polycross seed production. After renoting the plants in 1948 those selected in the other species will probably be transplanted to a new field and held vegetatively until it is planned to study them intensively and to produce polycross seed.

The Red Clover Uniform Disease Nursery is being continued with a new seeding established in 1947.

The polycross seed of all of the clones of the varieties and species described in the 1946 annual report, page 58, which were selected from the Agronomy Department plots were planted in replicated 10-foot rows except those of the English Meadow Foxtail where insufficient seed was harvested. Good well-established stands were obtained. A special planting of 10 clones of S.143 orchard grass, 5 clones of Brage orchard grass, 5 clones of bromegrass and 10 clones of New York red fescue was established. Clonal progenies were established by cuttings in spaced-plant rows and solid plant rows; selfed progenies were established by transplanted seedlings in spaced-plant rows; and polycross progenies were established by transplanted seedlings in space-plant rows and by direct seeding in solid-seeded rows and in plots. The variation in performance for several characters among the different kinds of progenies of a selected plant will be studied as well as the variation in performance among the different methods of planting within a given type of progeny.

Seed was harvested in 1947 from the isolation plots of Cornell 1777 and 4059 timothy.

The zigzag clover plots were continued in 1947 but no yields were taken. The surviving clones will be removed in 1948 for further testing and the old stands discarded.

The cytological studies of plants of birdsfoot trefoil collected from natural stands were continued, and all plants were found to be either "narrow-leaved" diploids or "broad-leaved" tetraploids. A few plants from colchicine treated seedlings were found with both doubled and undoubled shoots, from which cuttings were taken for planting in the field.

Title: Strain testing and breeding of forage plants for New York State and vicinity with special emphasis on problems of production during periods of midsummer drought.

Leaders: R. P. Murphy, S. S. Atwood, H. A. MacDonald, H. R. Fortmann and C. N. Hittle.

The varietal plots seeded in 1945 as part of this project were continued in 1947. Good results were obtained from those plots which

had become well established, as already described (1946 Annual Report, page 59). In addition, the plots seeded in 1946 produced good results in 1947. These 1945 and 1946 plots were established at Ithaca and at Churchville. New seedings were made in 1947 at Ithaca, Churchville, and Tully. All of these plots are being studied cooperatively by staff members in the Departments of Plant Breeding and Agronomy. A small seeding of alfalfa and bromegrass varieties was made in 1947 in Columbia County, in cooperation with the county agent. Extensive plantings of plots for the determination of hay or grass silage and aftermath production are established now for alfalfa, red clover, timothy, bromegrass, orchard grass, reed canary grass, meadow and tall fescue and tall oat grass. The alfalfa studies are reported separately in this report (page 8) under the Cooperative Projects. In some of these plots, the species are seeded alone, whereas in others they are seeded in mixture. In addition a small plot test with varieties of Kentucky Bluegrass was established in 1947 at Ithaca, seeded alone and in mixture with white clover.

Although these plots have been seeded for only a short time a few indications of results may be given. The "Southern" varieties of bromegrass seem to be higher in yield than the "Northern" types either grown alone or in mixture with alfalfa. In the other species none of the unnamed varieties or strains seem to be very much better than commercial seed. The new red clover varieties will be tested for the first time in 1948. Ranger, Buffalo and Atlantic alfalfa have not appeared to be superior in these short time stands to Grimm, Ontario Variegated or to some of the other lots of Northern grown seed. Some of the late varieties of timothy, Medon and Drummond, as well as Milton, Lorain and Boon appear to be promising. Brage orchard grass shows some promise as it is later than commercial and similar in hardiness. The Welsh strains of timothy do not appear to have a place because of low vigor. The Welsh strains of orchard grass do not appear to be sufficiently winterhardy for many conditions in the state. The tall fescue strains seem to be slightly superior to the meadow fescue strains but none of them appear very promising. Some seed lots of reed canary grass, seem to be superior to the others and to offer some promise for grass silage and aftermath production. The yields have been good with Ladino clover.

Ladino clover has performed very well for aftermath production in 1946 and 1947 when grown with the different varieties and strains of timothy, orchard grass, reed canary grass, tall oat grass and meadow and tall fescue. Good stands with all species and varieties have been maintained, even with timothy varieties cut for hay about July 15 to 21 in both years and with reed canary grass. These plots occur on a heavy soil type of the Volusia series.

The study of aftermath growth of bromegrass at controlled high temperatures in cooperation with the U. S. Plant, Soil and Nutrition Laboratory is being continued. No controlled experiment in connection with this study was planned for the control rooms in the winter of 1947-48. It was felt that more data on field performance of the clones already tested under controlled conditions should be obtained

at this time. The data from the test of last year when several selected clones of each of several species - orchard grass, tall oat grass, timothy, bromegrass and meadow foxtail - were included have not been completely analyzed. Some of these species did not respond to this method of testing as well as bromegrass.

The cooperative work with the Nutrition Laboratory is being continued in the winter of 1947-48. One control room has been filled with 90 individually potted plants of bromegrass for seed production. An effort is being made to make all possible single crosses reciprocally among 10 selected self-sterile clones of bromegrass. The seed will be used to study the specific combining ability of these clones by studying their single cross progenies planted probably as spaced plants. This study will be continued in the future under the preceding project.

Tests with five strains of bromegrass fertilized with different rates and times of application of ammonium nitrate and grown in association with alfalfa were continued during the 1947 growing season. Yields under three management systems were obtained. Nitrogen content of the forage has been determined. The data are now being summarized and analyzed. A duplicate experiment on a different soil type was seeded in the Spring of 1947. Data will be collected on both series in 1948.

Title: The Value of birdsfoot trefoil as a pasture legume in New York.

Leader: H. A. MacDonald.

Investigations relative to birdsfoot trefoil as a forage legume were continued during 1947. In replicated trials this legume outyielded the white clovers and proved to be more persistent than alfalfa under grazing conditions. Of particular significance has been the maintenance of productivity during the summer and fall period when many pasture crops are reduced in yield. Birdsfoot trefoil in association with tall fescue (Alta) gave a sustained yield higher than any other combination studied. Birdsfoot trefoil with brome grass also performed well.

Several selections of promising clones of birdsfoot trefoil have been made. These include a range of type material from the tall growing meadow types to plants quite prostrate in growth habit. One selection is now in preliminary increase.

Seed production still presents a major problem with this crop in this area. Considerable effort is being directed to this phase of the investigation with promising results.

Title: The Effect of Stage of Growth Upon the (1) Nutritional Values, (2) Yield of Hay and Aftermath and (3) Longevity of Stand of the Principal Perennial Forage Grasses and Legumes.

Leader: H. A. MacDonald.

Progress: The data from the first established investigation under this project have now been assembled but have not been completely analyzed. The crops used in this investigation were alfalfa, birdsfoot trefoil, Mammoth red clover, medium red clover, alsike clover, Ladino white clover, timothy, bromegrass, orchard grass, tall fescue, and tall oat grass.

Determinations made at the vegetative, bud, bloom, mature and post-mature stages include, (1) dry matter yield at specified stages, (2) dry matter yield of aftermath handled as pasture, (3) botanical composition of all treatments, (4) leaf/stem ratio of the legumes, (5) date at which various growth stages were reached, (6) height of crop at different growth stages, (7) chemical analysis of forage species (nitrogen, calcium, phosphorus, potassium, magnesium, manganese, and lignin (8) influence of time of harvest upon subsequent yield and plant population, and (9) influence of treatment upon residual soil fertility as measured by the growth of Sudan grass.

A new seeding in connection with the above investigation was established in 1946 and the first data obtained in 1947. A preliminary report of this project is to be presented in the near future.

Title: The Influence of the Methods of Grazing Management Upon the Yield, Chemical Composition, and Botanical Composition of Pasture Herbage.

Leaders: D. B. Johnstone-Wallace and W. K. Kennedy

This experiment was terminated in 1947. From the data collected it was found that cutting Kentucky bluegrass-wild white clover swards from heights of 8, 6, 4, or 2 inches to 1/2 inch usually resulted in only slight differences in dry matter yield. During the years 1943-1945 cutting from 8 and 6 inch heights was superior in yield to cutting from 4 and 2 inch heights. Cutting the sward to heights of 4, 2, or 1 inch resulted in significantly lower yields of dry matter than when the herbage was cut to a height of 1/2 inch. Cutting the herbage at different frequencies resulted in the highest yields of dry matter when the interval between cuttings was 6 to 8 weeks. Cutting at more frequent or at longer intervals usually decreased the yield of dry matter from a Kentucky bluegrass and wild white clover mixture.

No single system of grazing management studied produced herbage which was both of high yield, and of high quality throughout the

grazing season. However, the best results from a single treatment were obtained by cutting pasture herbage from a height of 4 or 5 inches to 1/2 inch throughout the grazing season. This method of management (1) provides as good or better seasonal distribution of dry matter yield than any other system of management studied; (2) provides herbage of high digestibility and nitrogen content throughout the grazing season; and (3) provides a sward which is tall and dense enough to insure the grazing animal an adequate supply of herbage.

The botanical composition was greatly influenced by the systems of management; the more frequently the pasture was cut the higher the percentage of wild white clover. Cutting to 1/2 inch at intervals of 3 to 6 weeks or from a height of 4 inches maintained the clover content of the sward at a level high enough to insure a high yield of digestible organic matter and herbage containing more than 2.5 per cent nitrogen equivalent to 16 per cent protein (N x 6.25).

The nitrogen, ether extract, ash, calcium, and phosphorus content of pasture herbage decreased, and the lignin and crude fiber content increased as (1) the height from which the herbage was cut increased, (2) as the height to which the herbage was cut increased about 1/2 inch, and (3) as the time interval between cuttings was increased. The close relationships of changes in lignin content to changes in nitrogen and crude fiber content are exemplified by the correlation values of -0.962 for lignin and nitrogen, and 0.899 for lignin and crude fiber.

The use of regression formulae was employed to evaluate yield from the various clipping treatments in terms of digestible organic matter. It was found that the increase in yield of dry matter from plots cut at intervals of 8 to 12 weeks, as compared with plots cut at intervals of 3 to 4 weeks, was largely nullified by the decrease in digestibility.

Title: The Herbage Quality and Quantity of Forage Species Grown Under Various New York Environments.

Leaders: R. E. Blaser, R. Bradfield, H. A. MacDonald.

Object: To obtain data on the compatibility, longevity, productivity, and chemical and botanical composition of pasture grasses and legumes in simple and complex mixtures under various ecological surroundings in New York.

Procedure: Field plots will be established on experimental fields and/or on farms of cooperators in different locations which typify New York environments. The areas will be fallowed for one season, provided this is necessary to eradicate species that cause contamination. The grasses will be used singly with a legume or a mixture of legumes under several fertility levels. For testing the legume species a single grass or mixture of grasses will be used, leaving the leguminous species as the variable. At least two cutting intensities will be superimposed on the seed mixtures.

The data on yield and on chemical and botanical composition will be associated with the ecological variables. Data on soil analysis will be obtained and associated with responses, if possible.

Progress: One field test was established during 1947. Additional tests will be started in 1948.

Title: Factors which Influence the Longevity, Seasonal Growth, and Productivity of Ladino Clover.

Leaders: R. E. Blaser and E. M. Kroth.

Object: To obtain information that will aid in developing long-lived and productive Ladino clover meadows and pastures. Longevity, winter survival, summer survival, productivity, and seasonal growth as affected by the following will be studied:

1. Presence and absence of grass associates.
2. Density of grass associate.
3. Fertility, including rate and date of application.
4. Moisture potential.
5. Cutting and grazing management.
6. Presence and absence of winter cover.
7. Age of stands.
8. Presence and absence of seedling populations.

Procedure: Field and greenhouse tests will be established to study the objectives given above. Cutting treatments will be used to simulate grazing intensities, until grazing animals are available. Data on yield, chemical and botanical composition, shoot and stolon populations and carbohydrate reserves will be obtained. If possible, these quantitative data will be associated with the ecological variables, including soil tests.

Progress: Preliminary data from one field test are available. It was postulated that June applications of potassium, after removal of a hay or silage crop, would stimulate summer growth of Ladino clover. Potash fertilization was influential in augmenting the mixed aftermath growth (Ladino, timothy, and quackgrass). As a result of June applications of potassium, the yield of Ladino clover was approximately doubled when compared with the mean yield of untreated plots.

Phosphorus fertilization, with and without potassium, was not associated with the magnitude of the yield nor with stolon and shoot populations of Ladino clover.

Nitrogen fertilizer was used with a mixture of P_2O_5 and K_2O. Nitrogen fertilization diminished the yield of Ladino clover when the P_2O_5 - K_2O treatment served as a check. However, the Ladino yields from the nitrogen plots were higher than the mean yields from unfertilized plots.

Other field tests were designed and established, but no results are yet available.

Title: Alfalfa Snout Beetle Investigations.

Leaders: H. H. Schwardt and L. D. Newsom

During the 1947 season tests involving several acres showed that the alfalfa snout beetle can be controlled by the application of dusts containing DDT, benzene hexachloride, or chlordan. Five per cent of the toxicant was used in each dust and 50 pounds per acre were applied. Chlordan killed 95 per cent of the beetles, benzene hexachloride 83 per cent and DDT 72 per cent. Standard peanut hull bait in which sodium fluosilicate is the toxic agent was used as a check and killed 71 per cent.

In cage tests with the same materials chlordan again killed the highest percentage of beetles, but was not significantly better than DDT while benzene hexachloride and the peanut hull bait killed approximately equal numbers. However, dissection of surviving beetles from the cage tests showed definitely that chlordan entirely suppresses egg development. Thirty-six per cent of the surviving beetles from the DDT cages developed eggs, 33 per cent from the benzene hexachloride cages, 93 per cent from the check, and 98 per cent from the peanut hull baited cages. Apparently beetles exposed to chlordan, even though not killed, will not be able to deposit eggs.

Title: Clover Root Borer Studies.

Leaders: L. D. Newsom and H. H. Schwardt

Further studies on the biology of the clover root borer show that the insect has but one generation a year. Over wintering occurs mostly in the adult stage but a small percentage of larvae and pupae do successfully pass the winter. The main dispersal flights occur in late spring and early summer but smaller scale flights may occur in late summer. In several instances laboratory reared beetles have survived two winters and oviposited again during their second summer.

Studies on the root shoot ratio and the root reserves of infested and clean plants have shown that the clover root borer is responsible for commercial damage to clover plantings. Significantly more shoots per millimeter of crown diameter are produced in uninfested plants than in heavily infested ones. Chemical analyses indicate that the carbohydrate reserves of clean roots remain much higher than those of infested roots.

While the clover root borer can be fairly effectively controlled with well-timed applications of chlordan or benzene hexachloride, their high cost and the residue hazard make recommendations highly inadvisable at present.

PENNSYLVANIA AGRICULTURAL EXPERIMENT STATION

Title: The adaptation of Species of Grasses and Legumes to the Varying Soil and Climatic Conditions in Pennsylvania.

Leader: J. K. Thornton.

Forage yields and other records were obtained on plots at three locations, one being the first harvest year for a site of very poorly drained glaciated soil in northwestern Pennsylvania.

On the Clearfield County plots timothy was the highest yielding grass with alfalfa and with birdsfoot trefoil. Reed Canary grass was the highest yielder with Ladino clover. Tall oat grass was second in yield with all three legumes. It was noted that Helminthosporium leaf spot not only injured the brome grasses severely in August, but in some cases plants were entirely killed. Parkland brome was injured more than Lincoln brome. Birdsfoot trefoil plants were covered with Rhizoctonia fungus and severely injured during the period of high humidity in August. Whether this injury will prove to be permanent cannot be determined until next year.

On the Canfield soil site in Crawford County, timothy was highest in yield with alfalfa and with birdsfoot trefoil, and second high with Ladino clover. Tall oat was second high with birdsfoot trefoil. Brome grass was second high with alfalfa. A mixture of orchard and bromegrass was highest in yield with Ladino clover.

On the poorly drained site in Crawford County, which represents an extensive area, only two legumes were used. Ladino clover appeared to be better adapted than birdsfoot trefoil. Following is the order of yields of grasses with Ladino: 1 - Tall oat; 2 - Orchard-tall fescue; 3 - Meadow foxtail; 4 - Reed Canary; 5 - Timothy; 6 - Orchard; 7 - meadow fescue; 8 - Tall fescue; 9 - Red top. The yield of the commonly used mixture: timothy + red clover - alsike clover fell between timothy, Ladino and orchard-Ladino. During the past season growth of Ladino clover on the poorly drained plots was so great that it had spread into most of the birdsfoot trefoil and grass alone plots. It may not be possible to continue to obtain accurate yields from plots containing the latter legume.

Title: The Importance of Soil Amendments in the Establishment, Maintenance, and Production of Grasses and Legumes.

Leader: J. K. Thornton.

Yields were harvested for the third year from these plots located at Frenchtown in northwestern Pennsylvania on glaciated soil. There was an improvement, if any change at all, in the Ladino clover whether growing alone or in association with orchard grass, as measured by yields and by percentage of legume in the forage harvested. The same was true of birdsfoot trefoil. On the other hand the yields and per cent of legume in the alfalfa-bromegrass and alfalfa alone plots dropped below those for the previous year, although not markedly.

Results have not been analyzed statistically, but there appears to be no significance to the yield differences between applications of 1000 pounds of lime per acre and amounts up to 8000 pounds per acre for plots containing either Ladino clover or birdsfoot trefoil. Plots with no lime, whether fertilized adequately or not, yielded practically nothing at any time during the three years. Plots containing alfalfa showed marked and probably significant increases in yield for increments of lime up to 6000 pounds per acre.

Measuring the value of the crop produced after deducting the value of the lime, phosphorus, and potash applied there was a steady increase in return for all species by increasing the amounts of phosphorus from 0 to 750 pounds. Potash treatments have proved entirely ineffective in increasing yields of any species of plant over the check treatment on this series of plots during the last three years.

No lime nor fertilizer has been applied since the plots were seeded in 1944. The original soil had a lime requirement of 4½ tons per acre and had produced nothing but poverty grass (Danthonia) and other plants of low quality for many years previously.

RHODE ISLAND AGRICULTURAL EXPERIMENT STATION

Title: The Response of Strains and Mixtures of Forage Plants to Grazing.

Leader: Irene H. Stuckey.

In terms of highest total yields and satisfactory distribution of grazing during the season, the bromegrass-Ladino clover combination was better than any of the others in 1947. There appears to be no real difference in the performance of a northern strain of bromegrass in comparison with a southern strain if good quality seed is used but the northern strains seemed to be less resistant to leaf spot (Helminthosporium bromi). The plots containing the two strains of orchard grass with Ladino clover were grazed 7 times in comparison with 6 times for most of the other pastures but the yields for the season were 20% less than for bromegrass with Ladino clover. In 1946, orchard grass outyielded bromegrass on these pastures. The mixture containing alfalfa, red clover, alsike clover, timothy and redtop gave only one-half the totals of the bromegrass plots and nearly all of the growth was in the first grazing. Comparing alfalfa and Ladino clover where each legume was grown with either reed canary grass or perennial ryegrass, the pastures with Ladino clover yielded more as estimated from the samples cut before grazing and were grazed more often. Reed canary grass appeared to be eaten much less readily than in 1946 except during a rainy period in June. During the cold weather of early spring, and the dryest parts of the summer, the animals avoided it. This seasonal difference in palatability was probably due to a difference in succulence of the grass, since the grazing season in 1946 was exceptionally wet. Perennial ryegrass showed signs of winter injury and the legumes predominated on both plots containing this grass.

Title: Controlling Thistles on Pastures.

Leader: Irene H. Stuckey.

All three of the 2,4-D compounds used at the rate of 1:1,000 destroyed thistles without leaving patches of bare ground if the spray was applied when the plants were in the rosette stage or while the stem was elongating. After the flowers had developed, one compound, a triethanol amine salt, was still effective at this same concentration. The usefulness of 2,4-D for eradicating thistles on pastures will depend on the ease with which large areas can be spot sprayed.

VERMONT AGRICULTURAL COLLEGE

Title: Factors Affecting Establishment and Maintenance of Birdsfoot Trefoil on Two Soil Types.

Leaders: A. R. Midgley and K. E. Varney.

Birdsfoot trefoil is a long lived hay and pasture legume, which has been very successful on some farms but not on others. These differences are being studied with extensive field plantings on both a heavy clay and a rather light, sandy soil. Trefoil was planted with each of six different grasses to see which grass association is most desirable on these two soils. Very good stands were obtained in all cases. Yield data are being collected from frequent cuttings to simulate grazing, early-cut and late-cut hay. In addition to these different management treatments, factors affecting seed production are being studied.

Five different fertilizer combinations are also being tried. Present results show that birdsfoot trefoil responds to mineral fertility treatments similarly to other legumes. Nitrogen, on the other hand, stimulates excessive growth of weeds and other plants which give the slow growing trefoil too much competition.

Title: Fall vs. Spring Application of Nitrogen for Hay Production.

Leaders: A. R. Midgley and K. E. Varney.

Two years' data on four soil types show that greater hay yields are produced when high nitrogen fertilizers are applied in the spring than in the fall. This has been true for both sodium nitrate and ammonium sulphate. The average increase of spring application over fall was about 400 to 500 pounds of hay when 60 pounds of nitrogen were applied. Other results indicate that where smaller amounts of nitrogen are used the difference due to time of application is very small. If nitrogen is not used in excess of 30 or 40 pounds per acre, fall fertilization could be recommended. It is usually easier and more convenient to apply fertilizer in the fall and the grass plants get an earlier start than with the regular spring applications. Furthermore, the dairy farmer usually has more money in the fall to purchase fertilizer than he has in the spring after a long period of barn and grain feeding.

Title: Cytogenetics and Breeding Investigations with Forage Legumes.

Leader: A. Gershoy.

Trifolium medium: From more than 200 generally superior clones, 15 were set out in 1947 in an isolation polycross nursery. The selection was based on characteristics of tall, robust, aggressive growth, coarse foliage and early flowering. A second group of clones having characteristics of aggressive growth, less coarse foliage and delayed flowering will be placed in another polycross nursery in 1948. The combining value of individuals will be determined in progeny rows and bulked seeds used for field plot studies. A scarcity of nectar yielding plants late in the summer of 1947 in the immediate vicinity of both the large source nursery and a smaller plot used for diallel crosses, may have been the causal factor in the unprecedented visits of honey bees to zigzag clover flowers. These visits continued for over a week and supplemented those of bumble bees. Flower heads thus visited produced seeds moderately well. Field treatments such as early clipping, designed to bring about maximum flowering during a period of least competition from flowers of other, common forage legumes, in order to determine effect on frequency of visits by honey bees, will be made in 1948. Preliminary studies on control of chalcid fly infestation have been initiated. Yield data from replicated, seeded field plots indicate that carefully controlled physiological experiments should be designed in order to analyze the variables which influence the slow growth rate and low yields of this species when seeded in competition with grass and other legumes and when enduring overgrowth by weeds. Unless such data are obtained it will be difficult to evaluate properly the response of this species to standard agronomic practices.

Lotus corniculatus var. vulgaris: Twenty clones of the tall, European type, selected from a foundation nursery made up of progeny rows of several parents of known pedigree, were set out in 1947 in an isolated, polycross nursery. Five of these clones showing superior characteristics in the field will be tested in progeny rows, in 1948, for combining ability. Bulked seed will be used in field plot studies to determine the relative adaptability of the tall, European type under hay and pasture conditions.

Trifolium repens var. latum (Ladino clover), Octoploid, 8n, series. In 1947 the first polycross isolation field of 10 generally superior octoploid clones was set out. From several of these clones which appeared to have, under field conditions, best combinations of growth characters, seeds were saved individually for progeny tests of combining ability. In these particular clones several combinations of growth habits and morphological characteristics are represented. Bulked seeds of octoploid Ladino will be used in 1948 in field plot studies and pilot tests under farm conditions in small fields. Seeds from parent plants with thin, somewhat smaller leaves and those from parents with thick, frilled and larger leaves will be planted separately. New F-1 and F-2 octoploids were under observation in progeny rows in 1947; a tentative selection was made from these for a second

polycross nursery to be planted in 1948. Studies have been made of percentage of viable pollen and of seed set in various pedigrees. In some cases a comparison was made with corresponding data obtained in the parent 4n clones from which the octoploids were derived. As regards aggressiveness and recovery after cutting, in general, the performance as field transplants of the most aggressive and most luxuriant octoploids falls decidedly short of that of outstanding plants of 4n commercial Ladino clover. Thus far none of the selections at the 8n level possess the extraordinary spreading growth which is so characteristic of standard, commercial plants or of genetic selections at the 4n level made at the U. S. Regional Pasture Research Laboratory and elsewhere.

WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION

Title: Pasture Fertilizer Studies.

Leaders: F. W. Schaller and G. G. Pohlman.

Eight years' results have now been obtained from the study which is concerned primarily with rates and frequencies of phosphate applications to permanent pastures. The study will now be discontinued and the results summarized for publication as soon as chemical analyses have been completed.

Rainfall during the past year has been below normal and has resulted in poor stands of white clover and low yields on these plots. Throughout the eight-year period, rainfall has been a very important factor in the fluctuation of clover stands and total yields.

In general, total yields and stands of desirable species from any treatment were dependent mainly on the total amount of phosphate applied. Total yields for the eight-year period were about the same when the phosphate was divided into one-, two-, or four-year applications. The study indicates that on many West Virginia soils a good practice for fertilization of permanent pastures is to make an initial application of 800 lbs. per acre of superphosphate and follow this at approximately four-year intervals with at least 500 lbs. per acre of superphosphate.

Title: Revegetation of Hill-Land Pastures in West Virginia.

Leaders: R. M. Smith, D. R. Browning, G. G. Pohlman and F. W. Schaller.

Two pastures, near Morgantown, were reestablished by tillage, fertilization and seed in the spring of 1947. One of these pastures contained approximately 5 acres and the other 10 acres. Good stands of alfalfa, Ladino clover and orchard grass were obtained and considerable grazing was provided during the latter part of the season.

A 30 acre renovated pasture at the Wardensville Experimental Farm during the past year carried approximately 1 cow per acre for a four-month period, extending from mid-April to mid-July. This is especially significant since rainfall was so limited that bluegrass pastures in this area produced very little. This pasture was in its first year after renovation, and the vegetation was mainly alfalfa, Ladino clover and orchard grass. Beef steers grazed on the pasture made good gains.

An experiment was initiated in the fall of 1946 to test the feasibility of using calcium cyanamide as a killing agent prior to renovation. Calcium cyanamide at the rate of 1500 lbs. per acre was surface applied to a pasture sod at Lewisburg, which consisted mainly of Kentucky bluegrass, poverty grass and broomsedge and also to an old meadow at Morgantown which contained mainly tall oat grass with some Kentucky bluegrass. Three times of application were tested, namely October 15, November 15, and December 15. Seedings of alfalfa-orchard grass and Ladino clover-orchard grass mixtures were made on these areas, the following spring.

Estimates made in late April and early May of the vegetation killed by the cyanamide treatment showed that at Lewisburg the percentage of vegetation killed was 1, 2, and 10% respectively for the October, November, and December applications. At Morgantown the values were 3, 27 and 12% respectively for the 3 times of application. Observations made during the summer indicated that this amount of killing was far too low to permit establishment of legumes or grasses by early spring seeding. The unkilled vegetation was so greatly stimulated by the cyanamide nitrogen that all signs of killed areas were soon obliterated and new seedlings were unable to establish themselves.

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